A TEXT-BOOK

OF

TROPICAL AGRICULTURE

BY

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REVISED BY

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WITH A FOREWORD BY

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DIRECTOR, ROYAL BOTANIC GARDENS, KEW

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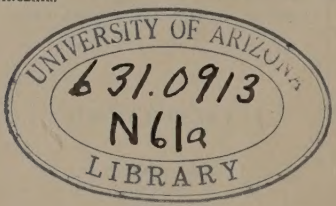
"If you wish success, make perseverance your bosom friend, experience your wise counsellor, caution your elder brother, and hope your guardian genius."—ADDISON.

"It is both the duty and interest of every Owner and Cultivator of the Soil to study the best means of rendering that soil subservient to his own and the general wants of the community; and he who introduces, beneficially, a new and useful *Seed*, *Plant*, or *Shrub* into his district, is a blessing and an honour to his country."—SIR J. SINCLAIR.



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PRINTED IN GREAT BRITAIN

To SIR JOSEPH DALTON HOOKER,

M.D., K.C.S.I., C.B., F.R.S., F.L.S., Etc., Etc.

Dear Sir Joseph,—

As a mark of my appreciation of the kind help and encouragement you gave me, when—during the last few years of your Directorate at the Royal Botanic Gardens—I acted as the Kew correspondent for Dominica, permit me to dedicate the London edition of my Text Book of Tropical Agriculture to you.

Had you not, on the death of our mutual friend, Dr. Imray, in 1880, urged me to endeavour to supply his place, or what may be described as an honorary Kew official on colonial service, I should probably not have directed any attention to economic botany. The most kind letter you then wrote to me has influenced me up to now; and, if there be anything useful in the following pages, the credit is due in a great measure to you.

In dedicating, then, this book to you, I am afforded the sincere pleasure of showing you that, in the quiet of your retirement, the influence of your work as the Director of Kew lives on and bears fruit even in this far-away field.

Believe me, always,

Yours faithfully and most sincerely,

H. A. ALFORD-NICHOLLS.

St. Aroment, Dominica.

30 *May*, 1892.

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FOREWORD

As this book was originally dedicated to Sir Joseph Hooker, it seems fitting that I should supply a foreword, especially as the revision has been undertaken by Mr. J. H. Holland, Assistant in the Museums, Royal Botanic Gardens, Kew.

The original book was written in 1892 and was intended to be primarily a textbook for the use of schools and colleges in the West Indies, though having passed through seven reprints it has had a far wider circulation and influence. Since that time there has been a great expansion in the field of Tropical Agriculture. At that time little notice was taken of crops such as Para rubber, and the study of cotton cultivation in the tropics had received scant attention. The cultivation of tea in India and Ceylon had not been undertaken on an extensive scale, while the value of the tropics for the production of oils and fibres had not been realised, and the development of such industries on modern lines had hardly commenced. Sugar, coffee and cacao were perhaps the most important tropical crops, and the cultivation of plants yielding spices and drugs occupied a much more prominent position than it does at the present time.

The tropics at that time were, from an agricultural point of view, looked upon rather as countries with a moist humid climate, and very little was known of the economic possibilities of the vast areas of the dry tropics, where the majority of the populations lived and found their sustenance. The crops of these regions, on which the people existed, were but little known, and much still

remains to be learnt of this aspect of Tropical Agriculture.

It is impossible, within the covers of a single book, to deal with the many crops of the tropic regions with any thoroughness, and the treatment of any crop, therefore, is rather in the nature of a short summary than an exhaustive treatise. This is especially true of the crops whose products enter largely into the commerce of the world, on each of which whole volumes have been published. Nor is it possible to adapt such information as is given to suit all the vast areas of the tropics with their varying conditions of soil, climate and peoples. A general treatise such as the present revision must be largely an indicator of the sources of special information, and the list of references given at the end of each chapter should be a valuable aid in this direction.

Written as it originally was, primarily for assisting agricultural development in the West Indian Islands, the original text of Dr. Nicholls' book has been retained as far as possible, and much of the information, as well as the methods of cultivation described, which are particularly suited to this part of the tropics, have been retained.

A good deal of additional matter has been added, and it is hoped that, in its revised form, it will be found as useful to those concerned in Tropical Agriculture as was the original work compiled by the late Sir H. Alfred Nicholls, who did so much to advance improved methods in Tropical Agriculture in the West Indies and in particular in Dominica, where his beneficent influence will always be most gratefully remembered.

ARTHUR W. HILL.

Royal Botanic Gardens, Kew,
April 1929.

PREFACE
TO THE FIRST EDITION

THE Jamaica Government having offered a premium for the best Text-Book of Tropical Agriculture specially adapted for the use of the colleges and higher schools in that colony, the author sent in the manuscript of a portion of this book—under the motto *Respice finem*—to compete for the premium. The committee appointed to decide the question adjudged the premium to the author's manuscript, on the condition that he carried out a promise to extend the book by adding several chapters treating of most of the cultivated tropical plants not noticed in the original work. This was done, and the book was published by the Government of Jamaica last year.

In the preface to the Jamaica edition the author expressed the hope that the work would prove serviceable to peasant proprietors, to owners of small estates, and to intending settlers in tropical countries. This hope appears likely to be realised ; whilst the commendations

of the West Indian press, and the adoption of the text-book by the governments of other colonies than Jamaica, indicate that it has supplied a distinct want.

The success that has attended the book so far is due probably to the fact that it is not a mere compilation, but the record of experience that has been gained by study, observation, and experimental cultivations.

Twelve years ago, when the author had to direct his attention to tropical agriculture, there was no practical book that he could turn to for help in all the difficulties that were constantly cropping up in his path. Knowing, therefore, the obstacles that usually beset the inexperienced planter, who is not content to follow the old grooves of unscientific agriculture, the author has so written the second part of this book as to afford the information he needed greatly in his own planting novitiate. This has rendered it necessary to enter into details which to the experienced tropical agriculturist may appear superfluous, but the book is really intended as a guide for the young and the unlearned, to whom such details are likely to be of essential service.

Mr. D. Morris, M.A., F.L.S., the Assistant Director of the Royal Gardens, Kew, and for many years the Director of the Botanical Department in Jamaica, has very kindly undertaken to revise the work and to pilot it through the press. The author has, therefore, not only to express to Mr. Morris sincere acknowledgments

for his help and for the interest he has taken in the matter, but also to thank him for the greatly enhanced value that the book receives by going forth to the public with the *imprimatur* of so high an authority on economic botany.

The author has also to express his acknowledgments to Professor Oliver and the authorities of the Kew Gardens for the advantage of being able to illustrate the book with some scientifically accurate figures. The engravings of the coffee, the cacao, the tea, the orange, the nutmeg, the cinchona, the rice and the tania plants are copied from the guide to the Royal Gardens. The illustration of the coca plant and the diagram of the vanilla flower are from the Kew Bulletins; it is proper, however, to remark in regard to the last-mentioned, that Fig. 4 is an improvement on the original, as it shows the lamellum pushed up under the anther. The other illustrations are from the author's drawings.

H. A. A. N.

St. Aroment, Dominica.
30*th May*, 1892.

PREFACE
TO THE SECOND EDITION

In the prefatory remarks to the first edition I am confronted with the views of the author under the motto *Respice finem*, written at a period not far in advance of that when Tropical Agriculture meant little more than plantations, which to the majority were only thought of in terms of sugar. Looking towards the end as proposed, my main anxiety has been faithfully to record, or catch up as it were, with the progress of nearly half a century, a task that has not been without difficulty, in order to admit of keeping within the compass of a limited number of pages. In view of the laudable desire all round, at the present time, to trade in Empire goods, it may be significant to note that most of the raw materials (apart from fruits—bananas, oranges, pine-apples—cereals, etc. included in this work) on which several of our great manufacturing centres depend, rubbers, fibres, oils, to quote a few examples only, the demand for which may be calculated in pounds by the million, are all products of the tropics; some, it is true, obtained from wild or forest sources, but mainly dependent on applied economic botany and agriculture. I have, for obvious reasons, made no attempt to deal with the important associative sciences of mycology and entomology. We have an Imperial Bureau for each, founded since the first edition was published, when the author ventured on the notes which have been left in their original form.

The omission of any details of the breeding and rearing of live-stock will, in like manner, be understood ; though the chapter on fodder plants may serve to urge the importance of this subject in relation to agriculture. In the economic research (if I may so use the term)—most essential at the outset to the farmer or planter—the first enquiries as a rule, converge on the study of the plants, and it is hoped that the present effort will at least form a useful vantage-ground. I need not, however, enlarge upon this subject as the full scope may be gathered from the foreword by Dr. Hill.

For development on a commercial scale, co-operation with the agricultural engineer is indispensable and I have to tender my best thanks to the various firms acknowledged in the course of these pages, for the loan of blocks to illustrate implements and machinery suitable for tillage or for treating produce up to the stage at which it leaves the hands of the planter or the exporter—otherwise when shipped f.o.b., c.i.f., or on ex-quay terms as the case may be, after which the consignments come in for handling by the marketing organisations and the manufacturer. I may add that the illustrations in most cases are not intended to show the full range that is possible, and when progress allows of more complicated or costly machinery it is advisable first to obtain proper specifications to meet the local conditions, expert advice on which the manufacturers would be ready to give at any time.

I am greatly indebted to the Director of the Royal Botanic Gardens, Kew, for the facilities afforded me in the reproduction of illustrations from the Kew Collections. My best acknowledgments are also due to the authors

and publishers of the various works from which figures have been copied.

Finally I have the pleasure to record my most grateful thanks to friends and colleagues—to Mr. H. C. Sampson, C.I.E., B.Sc., who read the proofs and gave me much useful advice, especially on the chapters including the coco-nut, coffee and cotton; Mr. L. A. Boodle, A.R.C.S., F.L.S., for reading through the matter in the first part, to Mr. I. H. Burkill, M.A., F.L.S., late Director of the Botanic Gardens, Singapore, who checked the pages on yams; and to Mr. R. F. Williams for his co-operation throughout in the preparation and checking of proofs and index.

J. H. HOLLAND.

Gunnersbury,
London, W.4.
24th May, 1929.

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PART I

THE ELEMENTS OF AGRICULTURE

A TEXT-BOOK

OF

TROPICAL AGRICULTURE

CHAPTER I

INTRODUCTION

What Agriculture means.

AGRICULTURE is a compound word, made up of two Latin words (*ager*, a field, and *cultura*, cultivation, meaning the cultivation of the soil); but, like many other foreign words now forming part of the English language, it means more than its two Latin roots, taken by themselves, would lead one to suppose. By Agriculture is meant, then, the art of cultivating or tilling the soil so as to make it give the largest possible quantity of vegetable produce for the use of man and domesticated animals.

Agriculture an important and noble profession.

From the earliest times in the history of the world, man has tilled the soil, and Agriculture has always been considered one of the noblest and most useful occupations of mankind. Baron Liebig, the great Agricultural Chemist, said, "There is no profession which can be compared in importance with that of Agriculture, for to it belongs the production of food for man and for animals; on it depends the welfare and development of the whole human species, the riches of states, and all industry, manufacturing and commercial. There is no profession in which the application of correct principles is productive of more beneficial

effects, or is of greater and more decided influence." If, then, so much depends on Agriculture, how necessary is it for people to possess a proper knowledge of its principles! Indeed, it is found that in places where cultivators are acquainted with the art, the crops are large, the people are richer, and there is more general prosperity than there is in those countries where the principles of proper cultivation are not usually known.

Proper knowledge of principles necessary for success.

West Indian planters ought to be successful.

In the West Indies, a planter who is industrious and who has a knowledge of Agriculture, need never despair of becoming prosperous, for most of the soil is as good as can be found anywhere else in the tropics. To the West Indian Agriculturist, then, industry and knowledge promise success and prosperity, and this fact must be borne in mind by all those who intend to devote themselves to the honourable occupation of cultivating the soil.

Plants grow,

and must have food.

All plants, whether small herbs or large trees, like animals, *grow*; that is to say, in their early life they are much smaller than when they have grown up. Anything that grows must have food. Animals obtain their food from plants or from the animals that have lived on plants, but plants obtain their food from the soil and from the atmosphere. In a wild state, as will be explained fully later on, plants get in this way enough food, upon which to live and thrive, but when they are grown in large quantities in order that their produce may be useful to man, the ordinary supply of food furnished by the soil and the air is not enough for their continued growth; and this fact accounts for the failure of crops when one kind of plant is grown for a number of years on the same land, without any attempt being made to supply the place of the food that the plant has taken up from the soil.

Food supplied by nature not enough for plants long cultivated in the same soil.

Object of the book.

The main object of this book is to show how all this takes place, and to explain how the plant-food may be given back to the soil and made ready to be taken up by the roots that are always in search of it.

CHAPTER II

SOILS

THE Agriculturist—or planter, as he is usually called in the West Indies and other tropical countries—has first to direct his attention to the soil, and it is necessary for him to know what is its nature before he sets to work to cultivate it. A knowledge of soils necessary.

HOW SOILS ARE FORMED.—All soils, no matter what their kind, have been formed by the gradual breaking down or wearing away of the hard rocks which in ages past formed the land. For countless years the wearing away of the rocks has been going on, it is going on now, and it will continue to go on as long as the world remains what it is. As the surfaces of these hard rocks slowly but surely crumbled away, the minute flakes and particles were washed down to the plains and the valleys, there to remain, or to be carried far distances, even to the sea, by the rivers formed by rains or by melting ice and snow. The breaking up of the rocks is brought about by various agencies, which will now be considered. Soils formed by wearing away of rocks. The particles worn off rocks carried to far distances.

GLACIAL ACTION.—In the arctic and antarctic regions, and in mountainous countries in other parts of the world, the snow collects in the more elevated places, and, by the pressure of its own weight, is formed into ice. More snow again falling on this, it becomes too heavy and too bulky to remain on the slopes of the mountains, and so it gradu- Snow made into ice.

ally slides down into the valleys, carrying away with it projecting masses of rock and grinding away the rocky bed over which it glides. The mass of ice and snow thus formed is termed a *glacier*, and its slow and grinding movement down the mountain slope is called *glacial action*. When the end of the glacier gets down to the warmer regions of the plains or valleys it melts and forms a stream of water; the larger portions of the rock it has broken off in its descent soon find resting places, but the finer particles of the hard rocks are made into mud by the water, and this is carried lower down into the valleys and deposited on the level parts or carried out to sea by the rivers.

Formation of glaciers.

In past ages the earth was very different from what it is now, the land was composed almost entirely of hard rocks, which, in many places, were covered with ice and snow. Indeed, in parts of the world where the climate is now warm and where the land is highly cultivated, there are evidences of glacial action still to be found, and most of the inhabitants little think that their rich soil has been, to a great extent, formed by the slow grinding action of the glaciers on the hard rocks which covered their country in past ages.

Transformations of the earth's surface and changes of climates.

THE ATMOSPHERE is one of the principal agents in the formation of the soil. It is made up for the most part of two gases, *oxygen* and *nitrogen*, with a small quantity of *carbonic acid*. It is the latter, which, with the help of water in the form of rain, snow, mist and dew, acts on limestone and other rocks and causes them gradually to crumble away. The softer portions are first attacked, and this accounts for the holes and crevices that are frequently found in exposed rocks. But even the hard portions are gradually worn away, and the whole process is seen going on in stone buildings, where, after a time, the sharp corners become rounded, and the smooth surfaces are roughened, by the "*weathering*" effect of the atmosphere. Weathering action on rocky material

Rocks worn away by the atmosphere.

nay also be well seen in churchyards, for inscriptions on tombstones are, after a time, completely obliterated by the destructive effect of air and moisture, whereas similar nscriptions on tablets protected in churches are unaffected after a number of years.

Rocks worn away by alterations of temperature.

VARIATIONS OF TEMPERATURE have also a powerful effect n the formation of soils. Rocks expand by heat and contract by cold. Thus in the hot tropical sunshine the surfaces of the rocks expand and are again contracted by the cool air of the nights; this causes them to crack, and then pieces flake off, thereby giving rise to a constant small, but certain, addition to the soil. In colder countries, frost has a very destructive action on all rocks. Water contracts by cold until it is near to the freezing point, but as it becomes frozen it expands. In cold climates this sudden expansion at the freezing point often gives rise to great trouble by causing water pipes to burst, for the force exerted by the expansion is so great as to burst strong iron vessels. It is easily understood, therefore, why rocks are split and crumbled by frost. Rain water soaking into the holes and crevices of the rocks, suddenly expanding with great force on freezing, splits them up into fragments, and thus allows fresh surfaces to be acted on by the atmosphere—which easily finds its way into all the open spaces.

Frost.

Soils formed by action of plants.

VEGETATION.—Plant life assists in the formation of soils in two ways. When the roots of a plant reach a rock, the acid sap eats into the surface dissolving out certain elements which are taken up by the plant as food, and liberating sandy particles which are added to the soil. Again, the roots enter into the crevices of the rock and by their gradual increase in bulk force the two sides apart, acting in this way like a wedge. The force thus exerted is very great, and even such delicate and soft plants as mushrooms can in their growth exert so powerful a pressure as to lift heavy weights. Some years ago,

in a town in England, a new stone pavement was laid down, and, to every one's surprise, after a time the heavy stones were mysteriously lifted out of their places. An examination into the matter showed that the earth under the stones had been mixed with the spores of mushrooms, the spores had grown and the mushrooms by their increase in size had lifted up the pavement. In the West Indies, where vegetation is vigorous in growth, the splitting up of rocks by the entry of roots into cracks and crevices can easily be investigated by any one.

The formation of soil by the combined action of the atmosphere and vegetation is a very important factor in the production of what is known as vegetable mould. A chemical change which may be described as a slow burning (or decay) is brought about by the action of the oxygen of the atmosphere on moist organic bodies, by means of which they are gradually consumed and resolved into their various constituents. In the case of trees and plants in the tropics this decay is very rapid, and the result is the large quantities of vegetable mould met with in tropical forests. In a very small way the same thing may be observed on rocky precipices, or even on walls. Lichens, which are flat, leathery kinds of plants, first attach themselves to the rocks and eat into the surface. The lichens die and decay, and add vegetable matter to the scanty soil formed by them with the atmosphere and moisture. Mosses then grow up, and they in turn die and decay, adding to the soil by their action during life and by their remains after death. Then small hardy plants appear on the scene, to give place in time to larger plants, until at last a shrub or a tree grows up and sends its roots into the cracks and crevices of the rock, with the final result that the rock is split up and crumbled away to form the soil for more vigorous vegetation. All this, of course, takes a very long time, but then the process has been going on for ages, so that it must have exerted a very considerable influence on the formation of soils.

An illustration of the formation of soils.

WIND, SEA AND RIVERS.—The *Wind*, in places, is a factor in the formation of soils, more especially in dry weather when sand and dust are sometimes carried long distances by strong breezes. The wind also carries straw, leaves and other light objects far away and in this manner often adds fertile matter to a poor soil. Action of winds.

The *Rivers* are constantly assisting in the formation of soils in various ways. In mountainous regions the particles worn off the rocks are carried down to the low-lands mainly by the action of the rivers: and the running waters, especially when in flood, grind down the rocks and stones by rolling them over and against each other. It will be noticed that the stones in the bed of a river are mostly smooth and round owing to this rolling action, the rounding off of the angles being caused by the constant friction or rubbing together. The mud and gravel brought down by slow-flowing rivers in times of floods are deposited in the plains or at the bottom of the valleys where they form *alluvial soil*, while in swift-flowing rivers they are carried out to sea to be spread along the bottom of the ocean. Action of rivers. Alluvial deposits.

THE SEA.—In some places the sea is gradually encroaching on the land by wearing away the shore by the incessant action of the waves, but in other places the reverse happens, for the sea becomes gradually filled up and so in time is turned into dry land. The mud and gravel brought down by rivers and glaciers form, as it were, a submarine soil, and by volcanic and other agencies, this soil has been in places lifted up above the sea to become in time land capable of cultivation. In some parts of the West Indies, the fact that the land has been formerly under the sea is plainly shown by the beds of coral found at some distance from the shore. In Dominica, for instance, which is a volcanic island, there are cliffs and beds of coral two or three hundred feet above the sea; and, as coral is built up in the sea by a marine animal. it is evident that parts of The sea bed formed into dry land. A part of Dominica formerly under the sea.

Dominica have been in past times below the surface of the ocean.

DISTRIBUTION OF SOILS.—We have seen that the soil has been formed for the most part by the gradual wasting away of hard rock, and we now know that the soil thus formed is brought down from the higher land mainly by rivers and glaciers and floods of rain—in other words by water in its ordinary or its frozen condition. Of course a portion of the soil stops on the slopes of the mountains when they are not too steep, but the greater part is carried farther down; and, as a rule, the finer the soil the farther it is carried. The big stones and rocks broken off by the glaciers —and the various other processes we have been considering—are left behind, and the smaller stones are carried lower down to form gravels, while the fine soil in the shape of mud is carried for long distances and spread over the land as sands and clays. If some mud be taken and stirred in a glass of water and allowed to rest, it will be found after a time that the mud will settle at the bottom of the glass and the water will remain clear on top of it. And this is what occurs, and has occurred since the world was created, in regard to the fine particles of rock brought down by floods, rivers and glaciers from the high lands. The mud has settled on the land and formed the soil that we now cultivate. In order to understand all this, it must be remembered that the world has not always been what we now find it. The land has altered in shape and elevation, the sea has been over much of the land, and the land of those days is now, in places, under the sea, and the climate of different countries, as we now find it, is quite altered from what it was many years ago. This is shown by the fossil remains of plants characteristic of hot climates being found in countries which, at the present time, have a temperate or even a cold climate. Unless we remember all these wonderful changes, and think of the thousands of years that have

Mountain soils.

Lowland soils.

The mud.

Fossil remains.

elapsed during which the natural forces we have been considering have been at work, we cannot understand how the soil could possibly have been made by the slow wearing away of granite and other hard rocks. But the more we study these great questions, the more marvellous does Nature appear to us to be.

The marvels of Nature.

Local Soils and Transported Soils.—As we have seen, the soil may be carried long distances by the agency of water and wind, and thus the soil may be found to be very different in its character from that made from rocks in the neighbourhood. When this occurs the soil is said to be *transported*. And when the soil formed in a place is not carried away but remains where it was made, it is said to be *local*, or *indigenous*, or *sedentary*—which really means that the soil is, so to speak, home-made, and not imported from other places.

Surface Soil and Sub-soil.—If a deep hole be dug in the land, it will usually be found that at some distance below the surface the character of the soil becomes altered. On the top the soil is darker in colour and much easier to dig, because it is looser; this is called the *surface* soil, and its darker colour is caused by the decayed leaves and roots and stems of plants it contains. The lighter and closer soil at the bottom of the hole is called the *sub-soil*, and it varies considerably in character. It may be made up of sand, or of gravel or clay, or it may be like the surface soil. The sub-soil may be a local soil, and the surface soil a transported one, or *vice versâ*, and when this happens they will usually be very different in their nature. The surface soil varies in thickness according to its position and surrounding influences. In forests and highly cultivated lands, it is usually deep, but on steep hill sides and in dry places, it is shallow.

Surface soil.

Sub-soil.

Earthworms.—Darwin, the great naturalist, has shown that earthworms exert a wonderful influence in the forma-

Earthworms aid in the formation of soil.

tion of surface soil. These most useful animals feed on the leaves and other parts of plants, and they burrow into the ground in all directions, sometimes even to the depth of five or six feet. In order partly to protect themselves from their enemies and partly to supply themselves with food, they drag half-decayed leaves and stalks into their burrows, and so block them up to a depth of two or three inches. Thus worms fertilize the soil by adding organic matter to it. The little heaps of earth often seen at the mouths of the burrows, more especially in wet weather, are called *castings*, and they consist of very fine particles of mould mixed with decayed vegetable matter. The worms make their burrows by swallowing the soil and then bringing it to the surface where it is got rid of in the form of these castings. In this way they continually turn over the soil, and besides, their burrows allow air and water to get easily into the earth, and also form channels for the roots of plants to grow along without difficulty. It is seen, therefore, that the humble earthworms are really working for the benefit of the planter; and so, on that account alone, none of them should be purposely injured or killed.

They drag decayed leaves into their holes.

They turn over and mix the soil.

CONSTITUENTS OF SOILS.—All sorts of soils are composed of five substances, namely (1) *Sand*, (2) *Clay*, (3) *Lime*, (4) *Vegetable Matter*, (5) *Stones*.

Sand.—This substance is well known to every one. It consists of fine particles of hard stone, which do not cohere when wet, and which fall quickly to the bottom when they are thrown into a vessel containing water. If sand be magnified it will be found to be made up of minute smooth stones with rounded edges, or, in other words, of very small water-worn pebbles. There are several kinds of sand commonly met with. Calcareous sands consist of grains of limestone, or of broken shells, as is often seen on the sea shore; hence we have coral-sands and shell-sands. Micaceous sands are largely composed of a shiny substance known

Nature of sand.

as mica. Sand, however, is principally composed of a glassy substance known by the names of quartz, flint, silica or rock-crystal. It has a gritty feel and it easily scratches such hard substances as glass. This property is sometimes made use of in the "sand-paper" sold in the shops. Sand makes the soil loose, and thus it assists the air and water in finding their way through the land, and aids the roots of plants in their efforts to penetrate in all directions. Quartz sand.

Clay is composed of two chemical bodies known as silica and alumina in combination with water. When dry it may be made into a powder, and when wet it becomes sticky and is then capable of being moulded into various shapes—and this property is known as *plasticity*. But when clay is burnt it loses its plastic property, for it then becomes hard and brittle. There are various kinds of clay, some quite white, from which china ware is made, others yellow, from which bricks are made, others again are red and are used to make pots, goglets and other earthen-ware articles. Clay is colder, and it retains much more moisture than sand. Nature of clay. Varieties of clay.

Lime usually occurs in soils combined with carbonic acid as a carbonate of lime. It came originally from the old hard rocks, but now it occurs in various forms, as chalk, lime-stone and coral. It is contained in large quantities in the shells of land snails and of some marine animals besides coral, and many of the lime-stones of the earth are composed entirely of these shells and deposits which accumulated at the bottom of the sea in past ages. Varieties of lime.

Vegetable matter exists in all soils upon which plants have grown. The leaves, roots and stems decay as already shown and form a dark brown substance called *humus* or vegetable mould. This occurs abundantly on the surface of the ground in forests and in less quantities in all cultivated lands. In some damp, hollow places where mosses and similar plants grow abundantly, the soil is composed almost entirely of humus, for the mosses grow up and die and decay, and Vegetable soils.

other mosses grow up on the dead ones, until, after numbers of years, the humus fills up the hollows and forms what is known as *peaty* land.

Stones useful in soils.

Stones are simply particles of the original rock from which the soil was formed. They vary greatly in size and shape. Some are rounded, others are sharp and irregular. If they do not exist in too great a number they serve a useful purpose in the soil, as they render the land lighter in character, while they assist in retaining moisture in the soil, and by their gradual wasting away slowly add material to the earth. For the stones are weathered by the atmosphere and other agencies in the same way as the rocks from which the soil was made.

CHAPTER III

SOILS (*continued*)

CLASSIFICATION OF SOILS.—Soils have been divided into classes, sub-classes, orders and species, somewhat analogous to what has been done in regard to the various members of the animal and vegetable kingdoms, but it is not necessary to do more here than to consider the eight principal classes, with their chief sub-divisions, into which the different soils are usually placed. Eight classes of soils.

The *first class* comprises the *clay*, or, as they are sometimes called, the *argillaceous* soils, which contain over 50 per cent. of clay. They are cold and difficult to work on account of their stiffness. Water does not run through them easily, and so they must be well drained in order to be properly cultivated. As clay loses its plastic or sticky property by being subjected to heat, it does good to a clay soil to pass fire over it or to burn it in heaps and then spread it over the land. Clay soils may or may not contain lime up to the proportion of 5 per cent., and thus they are divided into two sub-classes. Clay soils.

The *second class* comprises the *loamy soils* which contain from 30 to 50 per cent. of clay. These soils may also be with or without lime. Loams.

The *third class* is the *sandy loams*, containing from 20 to 30 per cent. of clay, and they are also sub-divided according to the presence or absence of lime in them. Sandy loams.

The *fourth class* is the *loamy sands*, and contains from 10 Loamy sands.

to 20 per cent. of clay; and like the other three classes, lime may be present in or absent from them.

Sandy soils. The *fifth class* comprises the *sandy soils*, which contain over 70 per cent. of sand, and they may also be with or without lime.

Marls. The *sixth class* or the *marly soils*, contain from 5 to 20 per cent. of lime, and they may partake of the characters of the first four classes, or of the eighth. Thus there are five sub-divisions of the marly soils.

Calcareous soils. The *seventh class*, or *calcareous soils*, contain more than 20 per cent. of lime, and they may partake of the characters of the first, second, third, fourth, fifth and eighth classes. Thus a *loamy calcareous soil* would contain from 30 to 50 per cent. of clay, and more than 20 per cent. of lime. And a *sandy calcareous soil* would have over 70 per cent. of sand, and more than 20 per cent. of lime.

Vegetable soils. The *eighth class* contains the various *vegetable soils*, in which humus or vegetable matter occurs in not less a quantity than 5 per cent. The vegetable soils may in their turn partake of the character of clayey, loamy or sandy soils, or be composed almost entirely of vegetable matter as in the case of bog and peat earth.

In each of the sub-divisions of the first seven classes the soil may be referred to three groups, namely poor, intermediate and rich, according to the quantity of vegetable matter contained in them. If we take, as an example, the first class which includes the clay soils, the presence of vegetable matter (or humus), if not more than a half per cent. would cause it to be classed as a *poor clay*. If there were above a half and not more than one and a half per cent. of humus it would be an *intermediate clay*, and where there is from one and a half to five per cent. of humus it would be a *rich clay*. Above five per cent. of humus would cause the soil to partake of the character of the eighth class and it would become a vegetable soil.

Classification of Soils (after Schübler and Wrightson).

Classes.	Sub-Classes.
I. Clay or Argillaceous Soils. (Over 50 per cent. of clay.)	1. With lime. 2. Without lime.
II. Loamy Soils. (30 to 50 per cent. of clay.)	1. With lime. 2. Without lime.
III. Sandy Loams. (20 to 30 per cent. of clay.)	1. With lime. 2. Without lime.
IV. Loamy Sands. (10 to 20 per cent. of clay.)	1. With lime. 2. Without lime.
V. Sandy Soils. (Over 70 per cent. of sand.)	1. With lime. 2. Without lime.
VI. Marly Soils. (5 to 20 per cent. of lime.)	1. Clayey Marl 2. Loamy Marl. 3. Sandy loam Marl. 4. Loamy sand Marl. 5. Vegetable Marl.
VII. Calcareous Soils. (More than 20 per cent. of lime.)	1. Clayey calcareous soil. 2. Loamy calcareous soil. 3. Sandy loam calcareous soil. 4. Loamy sand calcareous soil. 5. Vegetable calcareous soil. 6. Pure calcareous soil (without clay or sand).
VIII. Vegetable Soils. (More than 5 per cent. of humus.)	1. Clayey humus. 2. Loamy humus. 3. Sandy humus. 4. Bog or peat.

Each of these twenty-one Sub-classes are again sub-divided into three groups according to amount of humus in the soil, viz. :—

1. Poor. If they contain less than ½ per cent. of humus.
2. Intermediate. If they contain from ½ to 1½ per cent. of humus.
3. Rich. If they contain from 1½ to 5 per cent. of humus.

EXAMINATION OF SOILS.—We have seen that soils are classified according to the proportion of clay, sand, lime and humus they contain, and the presence of these substances in the soil may be very readily ascertained by the following simple experiments :—Weigh out a quarter of a pound of the earth after it has been well dried, boil it for a short time in a pint of water and then pour it into a glass vessel. A piece of blue litmus paper should then be put in, and if the paper turn to a red colour, it shows that acid humus is present in the soil, and that lime is necessary to counteract the acidity. More water is then to be added, the whole is to be well stirred, and the muddy water is to be carefully poured off into a large vessel, care being taken that none of the sand which settles to the bottom is lost. The sand is then to be stirred up with fresh water, which is again poured off into the larger vessel. And this is to be done several times until the sand becomes quite clean and free from mud. The contents of the larger vessel are to be allowed to remain for several hours until the fine mud settles to the bottom, when the clear water is to be carefully poured off. The sand and the mud should then be dried and weighed separately ; when, by comparing their weights with a quarter of a pound, the proportion of sand and earthy matter in the soil can be ascertained. To discover the presence of lime in a soil, it is only necessary to pour a little hydrochloric acid upon it ; this will cause effervescence if there be any lime, and the degree of the effervescence will give to an experienced observer a rough indication of the quantity of lime. To ascertain the exact quantity of lime, however, the acid must be allowed to remain some time on the soil, and then a solution of ammonia must be added. All the lime will, by this means, be dissolved out of the soil and it will remain in the liquid, from whence it can be thrown down by a solution of carbonate of potash or oxalate of ammonia. But this process can only be attempted by a person having some knowledge of chemistry. The proportion of vegetable

How to examine soils mechanically.

Lime effervesces when hydrochloric acid is poured on it.

matter or humus, in the soil, is ascertained in a rough manner, by heating for an hour to a red heat, a given quantity of thoroughly dry earth in an iron or clay vessel, when the vegetable matter will be burnt off. The earth is then to be cooled and weighed, and the loss in weight will give the proportion of humus in the soil. Organic matter destroyed by heat.

HEAVY AND LIGHT SOILS.—It has been shown in the mechanical examination of soils that the sand, which is the heaviest part, falls to the bottom of the vessel when stirred up with water, and that the clay being lighter is suspended in the water for a time and can be poured off so as to leave the sand by itself. This shows that sandy soils are heavier than clay ones—indeed, a cubic foot of sand will weigh from 30 to 35 pounds more than the same quantity of clay. But agriculturists call a clay soil a *heavy* one, and a sandy soil a *light* one. These terms, however, refer,—not to the relative weights, but to the facility with which the soils are worked. The clay being tenacious or sticky, it is much more difficult to plough or to dig than a sandy soil, in which the particles of sand move more easily one on the other and allow the implements to pass freely through the land. Sometimes these soils are called *stiff* and *free*, instead of *heavy* and *light*, and these are perhaps better names, for the reason that they are not likely to confuse any one. Clay soils retain much more moisture than sandy soils, as is well known, and this causes a great difference in regard to their temperature. Clay soils are therefore spoken of as *cold*, and sandy ones as *warm*, but a well-drained clay soil may be warmer than an undrained, low-lying, sandy soil, and this indicates the necessity for proper drainage of land; for, as will be shown later on, a certain degree of warmth is requisite for the propagation of plant life. Clay soil difficult to work. Clay soils retain moisture.

THE POWER OF HOLDING MOISTURE is possessed in a greater or less degree by all soils. If the end of a strip of blotting paper be dipped into water, the water will run up Retention of water in soils.

the paper for some distance. The same things occurs when the end of a wick of a lamp is dipped into oil. This action is known as *capillary attraction*, and all soils are capable of exerting such an action, which is one of the greatest importance from an agricultural point of view. Sand possesses this power to the least extent and clay to the greatest, and this accounts for the well-known fact that a clay soil is always wetter than a sandy one placed under the same influences. In order to find out the power of any soil to hold water, it is only necessary to place a known quantity of the earth, well pounded and dried, into a glass vessel and to pour water upon it until it is more than covered. It is to be allowed to soak for a day and then the water above the earth is to be carefully poured off. The weight of the remainder compared with the weight of the dry earth will give an idea of the capability of the soil for holding moisture. Another ready way is to take a flower pot, to fill it nearly to the top with dry soil, and then to weigh it. (The weight of the pot, both wet and dry, must, of course, be known.) Then gradually pour water on the soil until it begins to drop from the bottom. As soon as the dropping has ceased weigh the whole, and in this manner the proportion of water held by the soil is approximately arrived at.

Power of soils to hold water.

CHEMICAL COMPOSITION OF SOILS.—It has been shown that the greater part of all soils has been formed by the wasting or decomposition of hard rocks, and naturally the same substances that occur in the rocks, will be found in the soils also. Chemists have found out that every thing in the world is composed of elementary substances by themselves, or so combined together as to make up compound or complex bodies. These elementary or simple substances are termed elements, and they are of two kinds, namely, metals and non-metals. There are a good many elements, but it is unnecessary to enumerate them all here, as some of them—whilst useful in the arts and manufactures—are not at all

Chemistry of soils.

Chemical elements.

concerned in agriculture. Some of the elements are termed *organic*, because they were supposed, formerly, always to be found in organised beings—that is, in plants and animals; and the rest are called inorganic, as they are not necessarily present in living things. But organic elements occur in enormous quantities in inorganic substances, and inorganic elements are found in organised bodies, so that the terms organic and inorganic elements are now used simply as convenient expressions.

Organic elements.

Inorganic elements.

The organic elements are *oxygen*, *hydrogen*, *nitrogen* and *carbon*, which disappear as vapour or smoke when an organised body is burnt in the air. The first three are gases, and the last is a substance, one form of which, charcoal, is familiar to every one. Besides these, there are two other substances, namely, *sulphur* and *phosphorus*, which are sometimes called secondary organic elements, because they are frequently found in organised bodies. In all, then, there are six non-metals, as they are termed, ever present in fertile soils, and, in addition to them, there are five metals which are always to be found in combination with other elements, in lands suitable for cultivation. These are *potassium*, *sodium*, *magnesium*, *calcium* and *iron*.

Elements in the soil.

Eleven necessary elements.

Oxygen is an invisible gas which enters largely into the composition of the atmosphere; and in combination with another gas, hydrogen, it forms water. It combines readily with other elements to form different compounds called *oxides*. If iron be exposed to air and moisture its surface rusts, and this rust is simply a combination of iron and the gas oxygen; it is in fact an *oxide of iron*. Oxygen also combines with carbon to form *carbon dioxide*, usually called *carbonic acid*, a compound gas that plays a very important part in plant life. In combination with the element silicon, oxygen forms the oxide *silica*, which is the basis of all sands; with potassium it forms *potash*; with sodium it forms *soda*; with magnesium it forms *magnesia*; with calcium it forms *lime*, and with aluminium it forms *alumina*, which is the basis of all clays.

Compounds of oxygen.

Oxides.

Compounds of hydrogen.

Hydrogen is the lightest of all the elements. It combines with eight parts by weight, *i.e.* half its volume, of oxygen to form water; and in combination with nitrogen it forms ammonia. Hydrogen is also an important part of nitric, hydrochloric, sulphuric and phosphoric acids.

Nitrogen, like oxygen and hydrogen, is an invisible gas, and like them also it plays an important part in all life. The air we breathe is composed of one-fifth of oxygen and four-fifths of nitrogen. The two gases are not combined, like oxygen and hydrogen in water, but are both *free* in the atmosphere — in other words they are mixed together mechanically and not combined chemically.

Carbon is not a gas, but in chemical combination with oxygen it forms the important gas, carbonic acid, which has been already alluded to. Carbon is an essential constituent of all plants and is obtained by them from the air, plants being able to extract it from the carbonic acid present in the atmosphere. Under the influence of light, the chlorophyll in the plant breaks up carbonic acid into carbon and oxygen, the carbon being retained by the plant and used in building up organic compounds, while the oxygen is returned to the air. This is just the reverse of what occurs in the case of animals, for they take in oxygen and breathe out carbonic acid; and thus, by a wonderfully wise provision of Nature, the poisonous carbonic acid breathed into the air by animals is taken up by plants in order that they may keep the carbon and restore the health-giving oxygen to the air.

Carbon forms the bulk of plants.

Respiration of animals.

The Atmosphere.—A good deal has been said about the atmosphere and it is so much concerned in the growth of plants, in the formation of soils, and in the processes whereby they may be kept fertile, that it is necessary for the agriculturist to have a correct knowledge of its nature. We have seen that the atmosphere, or the air we breathe, is composed of a mechanical mixture of the two important gases, oxygen and nitrogen, in the proportion of about one-fifth of oxygen and four-fifths of nitrogen. The oxygen, although in much less quantity, is the more active element, and the nitrogen

Composition of the atmosphere.

really only serves to dilute it and prevent it having too active an effect. Besides these two gases, the air contains *carbonic acid*, *ammonia*, *nitric acid*, *chlorine*, *sulphuric acid* and water in the form of *vapour*. The quantities of these substances, in comparison with the oxygen and nitrogen, are so small as to be scarcely perceptible, but then the atmosphere is so vast in its extent that even an extremely minute proportion in a given quantity is really an enormous mass in the whole.

Carbonic Acid, as we have seen, is taken up by the plants in order to build up their tissues, for the roots, stem, leaves, flowers and fruit all contain a certain amount of carbon derived from the carbonic acid of the air.

Formation of ammonia.

The Ammonia in the atmosphere comes from the decay of animal and vegetable bodies, from active volcanoes, and from the combustion of substances by heat, as when wood or coal is burnt in a fire. It would naturally appear, therefore, that ammonia would be more abundant in the air of large cities than in country districts, and careful experiments have shown that this is really the case.

Formation of nitric acid.

Nitric Acid is formed principally by the electricity, which is so often manifested to all by means of lightning. After a thunder storm, the air always contains a much larger quantity of nitric acid than it did before.

Salt in the atmosphere.

Chlorine, in the form of chloride of sodium—commonly known as salt—is found in the atmosphere, and its presence is due almost wholly to the influence of the sea. Small quantities of salt, as fine spray, are carried by winds and currents of air for wonderful distances inland.

Sulphur Dioxide and *sulphuric acid* are present in the air, especially in the neighbourhood of smoky towns, and sulphur compounds are also given off by active volcanoes.

Sources of vapour in the atmosphere.

The Watery Vapour of the atmosphere is often precipitated in the form of rain and dew in hot and temperate countries, and as snow or hail in colder regions. It is constantly given off by the leaves of plants and in the breath of

animals, but its principal sources are rivers, lakes and seas, from whence it is obtained by evaporation during the heat of the day.

The ammonia, nitric acid, chlorine and sulphuric acid of the atmosphere are carried to the earth by the rains, and so made available for the use of plants.

How plants obtain nitrogen.

Nitrogen is a very important constituent of plants. It is contained, as we have seen, in the atmosphere in a free condition, as well as in combination with other elements in the form of ammonia and nitric acid—which are carried down to the earth by rains. It also exists in the soil in chemical union with other substances, as nitrates. Ammonia, too, is formed in the soil by the decomposition of dead plants and animals ; it ultimately becomes converted into nitric acid, which then combines with certain mineral substances present in the soil to form nitrates, *e.g.* potassium nitrate, and these are readily taken up by the delicate hairs on the roots of plants, and it is in this way that the nitrogen used by plants is obtained.

Food taken up by the roots of plants must be soluble.

Active and Dormant Constituents of Soils.—All the substances taken up by the plant from the soil, must be capable of being dissolved in water aided by carbonic acid and some organic acid. If a portion of dry soil be soaked in pure water for a time, the water that is poured off will be found to be altered in character and taste, for the reason that it has taken up from the soil some of the *active* or *soluble* substances used as plant food. Perhaps, in a fertile soil, this will not be more than two parts in every thousand, so that nine hundred and ninety-eight parts are insoluble in water. But, if acids be added to the water with which the soil is soaked, a very much larger quantity of plant food will be dissolved out, and this is what occurs in the case of plants, for the delicate root-hairs dissolve out from the soil the active constituents by means of an acid fluid which always permeates the walls of these finest divisions of the roots. If the soil, however, from which all the plant food

Acid sap of the root-hairs.

soluble in acids has been removed, be spread out in the air and sun for some weeks and then be again soaked in pure water in an acid solution, it will be found that a small portion of it has become soluble and thus available for plant food. This part was, therefore, in the first instance, in a *dormant condition*. The alteration brought about by the exposure of the soil to the air is easily understood if the way in which rocks are weathered be remembered. For the small particles of the earth are merely minute fragments of rock upon which the same wasting influences act in the same way as in the case of the great masses of hard rock from which the soil was originally formed. These facts then, explain why tillage operations, which expose the under layers of the soil to the air and the sun, render the earth more fertile, and why the resting or fallowing of land restores fertility by allowing time for the air to permeate the soil and so to increase the soluble constituents.

The particles of the soil merely pieces of rock.

Why the soil is improve by tillage.

THE DOUBLE SILICATES.—All soils contain silica and alumina, and a considerable portion of these elements are combined together with other elements to form what are called *double silicates*. These are four in number, namely: 1—Silicate of alumina and ammonia; 2—Silicate of alumina and potash; 3—Silicate of alumina and lime; 4—Silicate of alumina and soda. Now all these substances are used by the plant with the exception of alumina—which is the basis of clay. But, although not a plant food, alumina, in its form of a silicate, is an important agent in the preparation of the food, for it combines with ammonia, potash, lime and soda in such a way as to give up these elements readily to the roots of plants in a soluble condition. It has been found that silicate of alumina combines most readily with ammonia, and then, in point of order, with potash, lime and soda. Thus, if silicate of alumina and potash be placed where it can get ammonia, it will part with the potash for ammonia and become a silicate of alumina and ammonia.

Importance of the double silicates.

And, in the same way, the soda, in a soda double silicate, will be given up for lime or potash or ammonia ; and the lime, in a lime double silicate, will be given up for potash or ammonia, if these substances be brought near to it. This property of the double silicates is most important to the agriculturist, and it has been made of much use in the system of applying artificial manure to land.

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CHAPTER IV

PLANT LIFE

A knowledge of plant life necessary.

As agriculture is the art of cultivating the soil so as to produce crops from the various plants of use to man, it is necessary for the agriculturist to have a knowledge of all that concerns the life of a plant.

Most plants usually consist of five parts, namely, the root, the stem, the leaves, the flowers and the fruit. There are some plants, it is true, that have one or more of these parts wanting, but it is unnecessary to consider them in this work, for the tropical agriculturist is concerned mostly with the ordinary flowering plants.

THE ROOT, which is called the descending axis of the plant, varies very much in its character. In the grasses and other plants, the roots consist of many fibres spreading out in the soil in all directions ; some of them, indeed, are much longer than the stem, as in the case of the maize the roots of which have been traced to the length of fourteen feet. Other roots, called tap-roots, send a thick prolongation of the main axis straight down into the soil, and give off small fibres at intervals ; the best example of this is the carrot, but coffee and cacao also possess tap-roots. Roots have two important functions : firstly, they fix the plant into the soil, or to the substance on which it grows ; and, secondly, they take up nourishment for the plant to live and thrive on. At their ends all roots become very small and tender, and give

Functions of roots.

Root hairs

off, in the region near the apex, numerous minute, hair-like structures, called *root-hairs*. The extremity of a root is covered by a cap of special tissue, which protects the delicate growing point, and enables it to make its way through the soil without injury. The root-hairs apply themselves to the particles of the soil, and absorb water and certain inorganic substances. The latter, dissolved in water, are taken into the plant, pass upwards in the sap, and are used in the process of nourishment of the plant. The root-hairs perish after a time, but, as the root grows in length, fresh root-hairs are continually produced by the new portions added by growth just behind the apex of the root. This region is therefore always supplied with absorptive root-hairs, and thus the roots, as they push their way through the soil, are able to search in all directions for the food-substances necessary for the well-being of the plant.

take up plant food,

and then perish, when fresh ones take their place.

THE STEM is sometimes called the ascending axis of the plant, because, when the seeds begin to develop, the minute stem always strikes up towards the air and light, whilst the roots strike downwards into the soil, avoiding light and air. In certain instances, however, the stem runs along the ground as in some grasses and other plants, or it may even run underneath the surface, thereby resembling the root.

Importance of leaves.

THE LEAVES are normally flattened structures attached to the stem, and their green colour is due to the presence of chlorophyll. In them some of the most important physiological processes of the plant are carried out. One of these is the assimilation of carbon (see p. 22), the chlorophyll being intimately connected with this process. A leaf consists typically of soft tissue called *parenchyma*, with a number of ribs or *veins* embedded in it, and a thin skin of special tissue known as *epidermis* which forms a complete external covering for the whole. The veins conduct water and food-substances, and also give support to the soft tissues, while the epidermis is protective. Numerous minute pores, called *stomata*, occur in

Their functions.

the epidermis, and through these, gases pass inwards and outwards. Thus water-vapour from the inner tissues passes out into the air, while carbonic acid gas passes from the air into the leaf, and oxgen, set free during assimilation, travels in the reverse direction.

THE FLOWERS are those parts of the plant concerned in the formation of fruit, and they are often remarkable for their beauty and their fragrance, or their peculiar construction. A typical flower consists of four distinct series of organs, arranged in a circle round the axis of the flower stalk. This arrangement may easily be seen in the flowers of the orange or the lime.

Four organs of the flower.

On examining one of these flowers carefully, five thick, small green organs, like stunted leaves, will be noticed on the outside and at the lowest part of the flower. This outer series of organs is called the *calyx*, and the separate parts are called *sepals*. In the case of the orange flower, then, the calyx consists of five sepals. Inside the calyx, and similarly arranged, is the *corolla*—composed of five leaf-like organs, white in colour and possessed of a delicious perfume. These are called *petals*, and so the corolla is described as being composed of five petals. Within the corolla comes a series of peculiarly shaped organs, called *stamens* and bearing at their summits yellow, hollow bodies, the *anthers*, filled with a fine dust-like substance. The fourth and last series of organs are called *carpels*, and collectively, the carpels form the *pistil*. Each carpel consists of a hollow lower part called the *ovary*, in which are found one or more minute bodies called *ovules*. The carpels are separate in many flowers, but in the orange they are joined together and become one body, which consists of the small round undeveloped orange, terminating in a club-shaped prolongation called the *style*. At the end of the style there is a sticky body, the *stigma*, and very frequently some of the dust from the anthers may be found adhering to it.

This dust, which is called *pollen*, acts when applied to the

Fertilisation of the flowers.

stigma in such a way as to *fertilize the flower*, that is, to cause the pistils to develop into fruit with seeds in them. Without this fertilising process taking place, no fruit can be formed, and the flowers would wither, die, and drop off the tree. As soon as the ovules become fertilized by the pollen, the compound pistil of the orange begins to grow into fruit. The sepals remain permanently attached to the stalk at the base of the fruit; the petals wither and drop off, as do also the stamens; the ovary grows rapidly to form the fruit or seed envelopes, and the ovules become in time the seeds from which new plants may be raised.

Numbers of flowers possess an arrangement of their parts similar to that of the orange; and from the description already given, it will not be difficult to determine which are the *floral envelopes*, as the sepals and the petals are collectively called, and which are the stamens and pistils. But very many flowers differ greatly from the type of which the orange may be taken as an example. Thus, for instance, instead of the floral envelopes being composed of two series of organs, there may be only one, as in the case of the lilies, and this single envelope is called the *perianth*, and it is made up of *perianth leaves*, which are usually highly coloured. The parts of the calyx, corolla and perianth may be separate leaf-like organs, or they may be joined together, making envelopes of a variety of forms. In the flower of tobacco (p. 33) the *corolla* is *gamopetalous* or united. In the case of the eddoe or tania, the *inflorescence*—which is the name given to the collection of flowers on the flowering stem—consists of a central axis on which are set numbers of stamens above and pistils below; each stamen is a *staminate* flower and each pistil is a *pistillate* flower; there is no calyx or corolla or perianth, but the inflorescence is protected by a large, yellowish, leaf-like envelope called a *spathe*—see p. 455: tania (*Xanthosoma sagittifolium*).

The floral envelopes may vary.

In some plants the stamens and pistils are in different

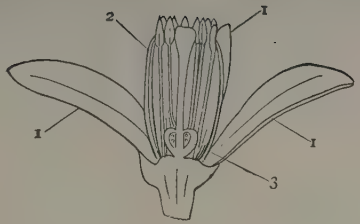


FIG. A.

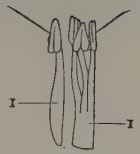


FIG B.

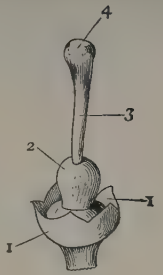


FIG. C.

THE ORGANS OF AN ORANGE FLOWER.

FIG. A.—A VERTICAL SECTION OF A FLOWER.
1. 1. 1. Petals. 2. Stamens. 3. Pistil.

FIG. B.—STAMENS.
1. 1. Filaments. 2. 2. Anthers.

FIG. C.—FLOWER WITH PETALS AND STAMENS REMOVED.
1. 1. Sepals. 2. Ovary. 3. Style. 4. Stigma.

The arrangement of the stamens and pistils.

flowers, described as *monœcious*. In others, as in the case of the nutmeg, the staminate or *male* flowers, and the pistillate or *female* flowers are produced on separate plants termed *diœcious*, and fertilisation can take place only by the wind blowing the pollen on to the *stigma*, or by insects or other agency. In some cases male and female organs occur together, the flower then being called *hermaphrodite*, and may be self pollinated, as in tobacco (p. 33).

Fertilisation of the date palm.

FERTILISATION BY WINDS.—The date palm, the fruit of which forms a very important portion of the food supply of many of the inhabitants of western tropical Asia and north Africa, is a diœcious tree usually fertilized by the agency of winds : and the people often secure a good crop of dates by climbing the female trees and shaking the pollen of the male flowers upon the female ones. Indeed, it has been recorded that some of the nations of Africa, when at war with each other, destroy their enemies' male date trees, which are much less numerous than the female ones, and by this means bring about a famine in the land. A female palm tree once grew in a hot-house in Berlin for eighty years without bearing fruit, when, on it becoming known that a staminate tree of the same species was flowering in Dresden, some of the pollen was sent for by post, and when it arrived it was sprinkled over the pistillate flowers with the result that the tree became fruitful and bore a crop.

Wind-blown pollen.

In cases where the pollen is carried by the wind for the fertilisation of flowers, it is exceedingly dry and light so that it may be wafted to long distances. A wonderful illustration of fertilisation by wind-carried pollen occurred in Italy. A palm tree grew in Otranto, it bore year after year many pistillate flowers, but no fruit was produced, although the tree was healthy and vigorous. After many seasons, a male tree of the same species blossomed at Brindisi, and soon afterwards the tree at Otranto was laden with fruit. The wind had carried the pollen a distance of

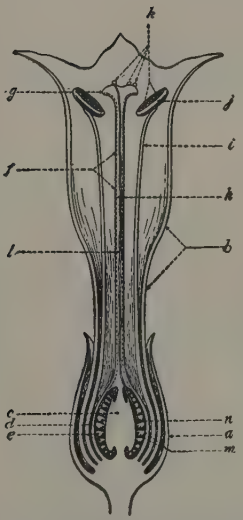
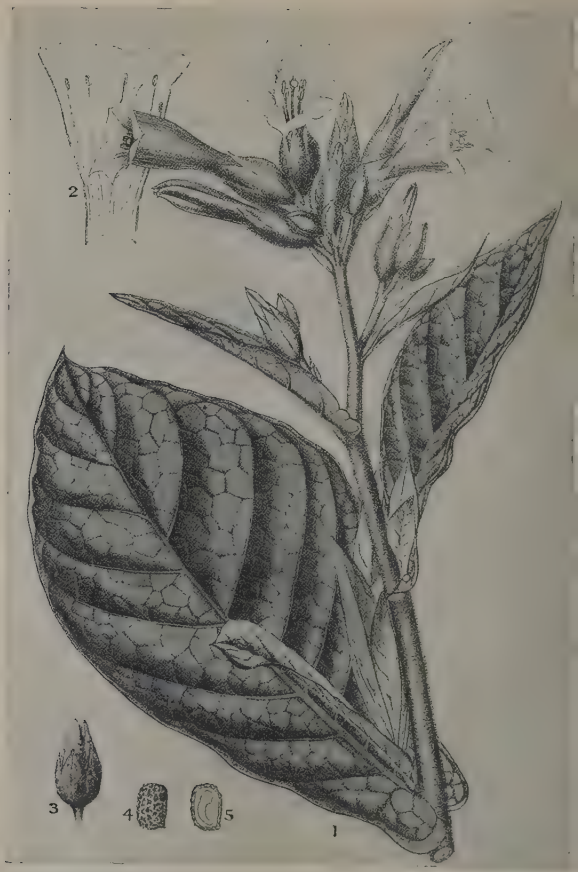


DIAGRAM OF TOBACCO FLOWER, LONGITUDINAL SECTION.

Illustrating pollination and fertilisation.

a, Calyx. *b*, Corolla. *c*, Placental tissue, bearing ovules. *d*, Ovary-wall. *e*, Ovules. *f*, Style. *g*, Stigma. *h*, Conducting tissue in the style. *i*, Filament of the stamen. *j*, Anther. *k*, Pollen grains. *l*, Pollen-tube on its downward course in the style (*f*). *m*, Micropyle. *n*, Ovule reached by pollen-tube.

[*Diagram from "Southern Field Crops," by J. F. Duggar.*



TOBACCO.

1, Inflorescence and young leaves. 2, Corolla split open. 3, Capsule wi
persistent calyx. 4, A seed. 5, Section of same (highly magnified).

[*From "Medicinal Plants," by Dr. Bentley and Dr. H. Trime*

twenty-four miles : and, year after year, although the trees were so far separated, the one was able to fertilize the other.

FERTILISATION BY INSECTS.—There are innumerable plants the flowers of which are unable to fertilize themselves, and are incapable of being fertilized by the agency of winds. In some instances, too, although perfect stamens and pistils occur in the same flowers, they do not develop at the same time, and thus the pistils of one flower must be fertilised by the pollen of another. This provision, which is called *cross fertilisation*, is very common, and it is a wise provision of nature to enable the plants to produce better seed. In other instances, as in many orchids, aristolochias, &c., the stamens are so situated as to be quite unable to cast their pollen on to their own stigmas, or on to the stigmas of other flowers ; and, therefore, the pistils could not be fertilised, and the plants could not produce fruit and propagate their species without the agency of insects or birds.

Most persons in the West Indies have noticed, at some time or other, butterflies, bees and humming birds flitting from flower to flower in the bright sunlight. The butterflies dart their long probosces right into the corollas ; the bees creep into the flowers ; and the humming birds, apparently motionless, but really beating their wings with wonderful rapidity, remain poised in front of a flower whilst they probe it to the bottom with their long and slender beaks. The humming birds, the bees, the butterflies, the beetles and the moths all go to the flowers to rob the *nectar* —a juice containing sugar secreted at the time of *pollination* —that is, when the stigma is ready to receive the pollen. This nectar is industriously collected by bees, and it is stored up by them in the form of honey. The nectar is secreted by glands on the axis or stalk to which the various parts of the flower are attached, and in some cases it is secreted

Humming birds and flowers.

The nectar attracts bird and insects

by similar glands or cushions on the petals or the stamens themselves. On examination, these organs may be seen as a small swelling or as special receptacles or spurs, from which the nectar exudes. All the various glands, cushions and receptacles exuding sweet juices, as mentioned above, are generally called nectaries.

Birds and insects fertilise the flowers, whilst they feed on the nectar.

We have seen how insects and birds go to flowers to rob the nectar, but nature has wisely provided that they shall, at the same time, render a service to the plant by assisting in the important process of fertilisation. Flowers are of an infinite variety of form; but, no matter how the several parts are arranged, insects cannot get at the nectar without coming in contact with the anthers, so that the pollen escapes and clings to them. And thus, when another flower is visited, the pollen is brushed against the sticky stigma and so remains to effect its important work. This is the commonest way in which flowers are fertilised by insects, but in other instances the arrangement of the flower to effect pollination is simply marvellous. *Aristolochia trilobata* is a curious climbing plant that grows wild in Jamaica, Dominica, and other islands of the West Indies. Its flower is very pretty; there is no corolla, but the coloured calyx is formed like a pitcher with a curved swan neck. This neck has a lid-like covering prolonged into a tail which freely waves in the wind and thus serves to arrest the attention of insects. The lid prevents rain entering the pitcher, but it allows free access to flies and other small animals. The inner side of the neck forms a tube leading down to the inflated bottom of the flower; and it is set with hairs all sloping away from the entrance, and with their points directed towards the interior; so that, although they offer no obstacle to an insect entering the cavity of the flower they effectually prevent its exit. A fly, then, entering the pitcher in search of nectar, is kept imprisoned until it has by its movements, caused the pollen to be applied to the stigma; and when this occurs, the hairs gradually collapse

A wonderful example of the arrangements of Nature to ensure fertilisation by insects.

and the fly is free to get out, carrying with it, however, some pollen grains that may be useful to effect cross-fertilisation in another flower. The bright colours of flowers, and their odours, seem to attract insects and other animals concerned in fertilization, and it is generally seen that those flowers dependent on animals for pollination, have some characteristic—whether of colour, form, or odour, which serves to attract the attention and invite the visits of their welcome guests. Thus we see that Nature has wisely arranged that, whilst the flowers are feeding the insects, the insects are fertilising the flowers, to the end that the species may be propagated, and that man and the lower animals may reap a fuller harvest from the soil.

The colour and the odours of flowers.

THE SEED, or as it is sometimes called, the *plant egg*, is composed of a very small body, the *embryo* or young plant, and a store of nourishment—made up usually of starch or oil—for the infant plant to feed on until it is able to take up food for itself. The embryo and the food are contained within two hard envelopes which protect them from injury.

The seed and the embryo plant.

THE EMBRYO is the miniature plant, and it is composed of the *radicle*, or root; the *caulicle*, or stem; one or two leaves, the *cotyledons;* and the bud, or *plumule*—which is usually packed away in a little pit at the base of the cotyledons. Of course all these parts, which correspond to similar parts of the developed plant, are very simple. They are in fact the rudiments or the unshaped beginnings of the perfect plant. The nourishment stored up in the seed for the first food of the young plant may be contained in the cotyledons—which are then thick and fleshy as in beans; or it may be apart from the cotyledons, as in the maize and the cocoa-nut; but all seeds contain a supply of it, for otherwise they would not be able to become developed into plants, as the radicle cannot take up food from the soil until it grows into a regular root.

The seed contains food for the young plant until the roots are formed.

The requisites of germination.

GERMINATION.—When placed under favourable conditions, the embryo begins to grow into the plant, and this vital action is called *germination*.

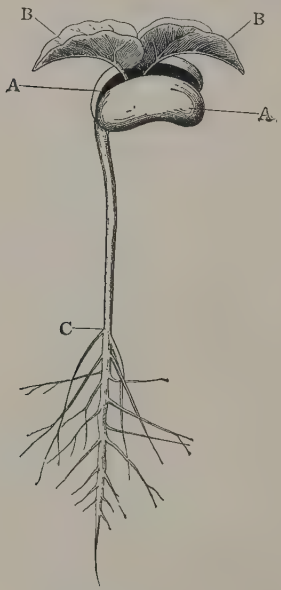


FIG. 1.

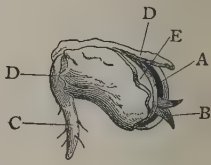


FIG. 2.

STAGES IN THE GERMINATION OF A BEAN.

FIG. 1.—A. Cotyledons. B. Plumule developing leaves. C. Radicle developing roots.

FIG. 2.—A. A. Cotyledons. B. B. Leaves developed from the Plumule. C. Roots developed from the Radicle. D. D. Outer envelope of seed. E. Inner envelope of seed.

The necessary conditions for germination are three, namely, the presence of *moisture*, *warmth* and *air*, and

when these three requisites are present in proper proportions the following process takes place:—The seed absorbs moisture which causes all the parts to soften and swell so as to burst the coverings and allow the embryo to grow; at the same time certain chemical changes are taking place, for the insoluble starch or oil present in the seed is converted into a soluble substance like sugar upon which the miniature plant feeds. The carbon let loose by this chemical change combines with the oxygen of the air to form carbonic acid. During all these changes heat is given off, and thus the seed is supplied with warmth, to a certain extent, by its own vital action, but outside heat is necessary in the first instance; for, without its presence, the life that is in the seed could not be, as it were, wakened from its sleeping condition.

The process of germination.

Chemical action set up.

Heat evolved

The embryo having burst out of the coverings of the seed, the radicle pushes downwards into the soil to form the root, and the plumule grows upwards to form the stem and leaves. Nature has endowed the embryo with this property, and nothing whatever can prevent the radicle from going downwards into the soil, and the plumule from growing upwards into the air. If a seed be so planted as to have the radicle directed upwards, it will turn downwards as soon as it commences to grow, and the plumule will also turn round and strike upwards—this may often be seen in the case of cacao and other seeds which have been planted with the wrong end upwards.

The growth of the embryo.

THE NUTRITION OF PLANTS.—It has been already seen that the infant plant is suplied with food from the store of nourishment kept for that purpose in the seed. But by the time the roots and leaves are formed, this supply has been eaten up, and the plant must now look to the soil and the air for its food. The leaves absorb the nourishment from the air, and the roots take it up from the soil by reason of the delicate hairs on their smallest fibres. In order that this process may go on, however, the nourishment must be dis-

How plants feed.

solved in water, for neither the root nor any other part of the plant can take up solid food. Sugar, salt and other such solid bodies, are easily dissolved in water; that is to say, the substances disappear in the water, but they still exist in a different form, as may be known by the taste. Now the water in the soil aided by carbonic acid and the acid fluid of the root-hairs, dissolves the various soluble substances in exactly the same way as water dissolves sugar. Ammonia, carbonic acid and compounds of lime, potash, &c., are always present in a soluble form in a fertile soil, and thus they can be taken up by the roots and used for the nutrition and growth of plants. The carbonic acid and ammonia in the soil comes from the rain (which brought them down from the atmosphere) and from the decomposition or putrefaction of the animal and vegetable matter in the earth, but the inorganic compounds are derived from the soil itself; which, as we have seen, has been formed out of the hard rocks.

THE COMPOSITION OF PLANTS.—The whole process of the nutrition of plants will be better understood after a knowledge of their composition is gained. If a plant be taken with its roots, stem and leaves, and destroyed by fire, nothing will be left but a small quantity of ashes. About 95 parts have been burnt off, and only about 5 parts remain. The 95 parts have disappeared in the form of gas or vapour; they are styled the *organic* or *volatile* portions, and they have come principally from the atmosphere. The ashes which are left are called the inorganic or mineral portions, and they have come from the soil. Sometimes the ashes are in larger or smaller proportions than 5 per cent., the limits being from 1 to 11 per cent., but 5 per cent. may be taken as the average quantity.

The ashes of plants.

The volatile portions of the plant are of two kinds, one containing all the organic elements except nitrogen—and called, therefore, *non-nitrogenous*, and the other containing

The organic portions are volatile.

all the four organic elements—and known as *nitrogenous*. In the former class are included *cellulose* or woody material, *starch*, *sugar*, *gums*, &c.: and in the latter class are included *protoplasm and chlorophyll*. Protoplasm is that part of the plant in which the principal vital functions are centred, and chlorophyll is the colouring matter of the leaves, and it is the agent specially concerned in decomposing carbonic acid so that the carbon is retained by the plant, and the oxygen is returned to the atmosphere. The inorganic portions of plants are *silica*, *chlorine*, *potash*, *soda*, *magnesia*, *lime*, *oxide of iron*, *phosphoric acid*, and *sulphuric acid*; sometimes, *manganese* and other mineral substances may be found in minute proportions. These inorganic elements do not occur by themselves or in a free condition, but they unite with each other to form compounds, as for instance in the superphosphate of lime which is composed of phosphorus, calcium, hydrogen and oxygen. A knowledge of the composition of the ashes of plants is of the greatest use to planters, for they are then able to determine whether a particular plant can be grown with success on certain portions of their lands. Thus, if the land be deficient in lime, and the planter wishes to grow plants that take up much lime, he knows that the plants will not grow properly unless he gives lime to the soil in some way or other. The inorganic parts of the plants, as shown by the quantity of ash, are very small, but they are as necessary to the well-being of the plant as is the water which is contained in the tissues in such abundance. A soil in which all but one of the necessary inorganic elements are found will not grow the plant, for the absence of the element occurring in the ashes in the smallest quantity renders the soil less able to produce luxuriant vegetation of the sort desired. This explains the wonderful help that agricultural chemistry renders to the farmer or planter. He first finds out what is the composition of the plant he wishes to grow, and then he has his soil analysed so as to see whether it contains all the

Importance of protoplasm.

The importance of chemical analysis of plants.

Soils should contain all the inorganic elements found in the plants.

Value of agricultural chemistry.

elements necessary for the food of the plants, and whether these elements exist in an active condition. If not, he knows what to add to the soil, in the form of manure, to make it fertile ; or, as we shall see later on, he finds out that tillage or rest will develop in the soil all the necessary substances in sufficient quantity and in a soluble form ready to be taken up by the roots of the plants.

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CHAPTER V

PROPAGATION OF PLANTS

In a natural condition, plants are propagated either by seeds, by bulbs and tubers, by runners, by suckers or by buds. Man has, by his knowledge, increased the means of propagation by dividing the plants, by making cuttings of the stem and roots and by employing the process known as layering. There are, then, two principal means of propagation, namely, natural and artificial. Both methods are made use of in cultivation.

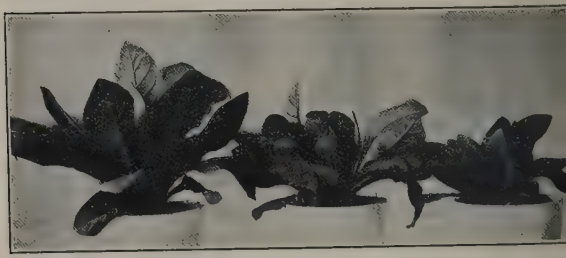
Two kinds of propagation, natural and artificial.

Propagation by Seeds.—In most instances plants reproduce themselves by their seeds and many of the crops grown by men are propagated in this manner. The production of seeds is the aim, and often the end, of the life of the plant. The seed falls to the ground and germinates, the plant grows, it becomes mature, and then it flowers and seeds—and often the seeding is the expiring effort of the organism. This is the circle of plant life, and it has been going on for countless ages in the same way as it goes on now. It will be noticed that many plants of the same kind vary greatly in regard to their size, their vigour of growth, their appearance of health, and the quality and quantity of their seed or fruit. Whilst one plant, growing in a good soil and under favourable conditions, will be luxuriant in appearance and prolific in its return of fruit—or seed or leaves or root as the case may be—another plant

Variation often due to external conditions.

of the same kind growing in a bad situation, and under disadvantageous surroundings, will be poor, sickly, stunted and nearly or altogether barren. The aim of the agriculturist is to produce healthy and vigorous plants which will give good crops, and one of the first things necessary to ensure that end, after he is satisfied that the soil and climate are suitable, is *to select good seeds* from the best plants. The value of selection is illustrated in the seedling tobacco plants here shown.

Importance of good seed.



YOUNG TOBACCO PLANTS.

Illustrating value of selected seed; the largest plant grown from the heaviest seed.

[*From "Southern Field Crops," by J. F. Duggar.*]

PROPAGATION BY BULBS AND TUBERS.—Bulbs and tubers may appear on plants either above or below the ground. In some yams both kinds are found in the same plant. If yams were left in the ground they would give off tubers and then the parent plant would die. Afterwards the tuber would grow up and form a collection of plants in the same place. But as these plants would be too crowded to thrive some would die, and thus the plants would be propagated by nature to a certain extent only. Man steps in, however, and separates the tubers, and by placing them all under favourable conditions he is able by artificial methods t

Yam tubers.

increase the number of plants from the parent yam—and, consequently, to obtain a much greater yield. This is a case in which natural methods of propagation are made use of by man for his own advantage.

PROPAGATION BY RUNNERS.—This mode of propagation is well seen in the strawberry plant and in some running grasses. A slender branch is sent off from the base of the stem, it runs along the ground, and at its end produces a new plant. The branch withers and dies as soon as the new plant is rooted. Some plants also have creeping stems rooting all along their under surfaces, and developing new plants from buds on the upper ones.

Creeping stems.

PROPAGATION BY SUCKERS.—Suckers are merely modifications of runners; they are branches, or more properly speaking underground stems, which may be very long or short, given off below the ground, and then, after rooting, they grow up into the air and eventually become independent plants by the decay and separation of the underground stem which connected them with their parent. The plantain and banana are familiar examples of this process of propagation, for they very rarely bear seed, and man is dependent on the suckers for the plant to supply the important food borne by them. Botanists make several divisions of suckers and runners, giving them different names according to their characteristics, but for all practical purposes the young agriculturist may consider runners and suckers as the two necessary divisions.

Banana suckers.

PROPAGATION BY LAYERS.—In certain instances this process, which is much used by gardeners to propagate plants, is a natural one. If branches of some plants by their own weight or by some accidental circumstances, bend down to the ground and remain still on damp earth, roots will be given off from the underside of the branch, and in time the branch may become an independent plant. This process

Layering often a natural process.

has been copied by man, who now propagates plants by it at will. The branch to be layered is bent down to the earth, or to the soil placed in a pot or a box, and kept immovable by a peg or by some other contrivance, and in order to stimulate the branch to give off roots, the connection with the present stem may be partly cut through, or be twisted or even broken. After a time roots will be formed and then the connection may be severed altogether.

PROPAGATION BY DIVISION.—This is a very simple and sure way of multiplying those plants that have many roots and stems—such for instance as guinea grass, cardamoms, ginger, arrowroot, &c. The whole plant is dug up, the earth shaken from the roots, and then it is divided into as many plants as it can safely give. Care must be taken that, at least, one growing bud is left on each divided plant, otherwise the new plant will not grow properly.

One bud at least to be left.

PROPAGATION BY CUTTINGS.—This is a very important way of propagation, for by it the individual peculiarities of the plant are maintained. In the case of seeds there is often a variation between the parent plant and the seedling, but this is obviated by multiplying the individual by cuttings. The cultivation of the sugar cane is carried on by cuttings, and bamboos, sweet potatoes, cassava, &c., are propagated in the same way. Cuttings should always be cut across as smoothly as possible, just below an eye or bud on the stem or branch of the plant, and in this way there is more chance of the cutting striking root. In the propagation of plants by cuttings on a large scale, as is done in the West Indies, sufficient care is not taken to secure good parent plants. The writer of this work has often seen sugar cane "plants," as the cuttings are sometimes called, taken from the worst and smallest canes in the field, and then the planters have been surprised afterwards to find their canes puny and backward. But a cutting will always reproduce the peculiarities of the parent plant, and vigorous sugar canes

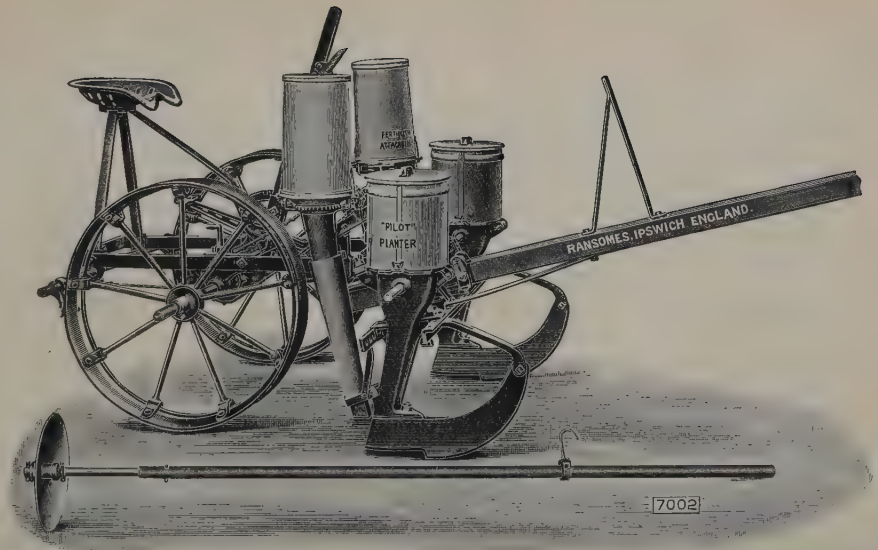
Seedlings often vary from parent plant.

Cuttings to be taken from the best plants.

cannot be expected to grow from cuttings of inferior plants. In the temperate and cold regions of Europe and America, where tropical plants can be kept alive only in hot-houses, their propagation is carried on chiefly by cuttings, and the gardeners have become very skilful in raising plants in this way. In fact many plants can now be raised from simple buds, or even from leaves or portions of leaves, but these processes do not much concern the tropical planter. It may, however, be pointed out that the principle of the process may easily be made out in the case of the common begonia, a leaf of which placed or pinned down on damp earth will eventually produce several perfect plants.

Plants raised from buds and leaves.

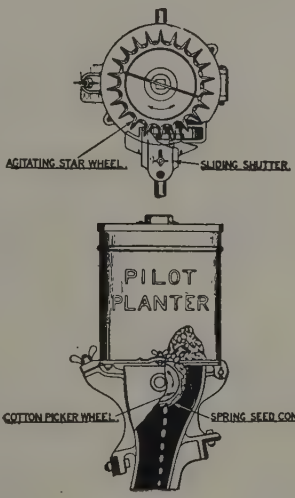
No special implements or machinery are required for any of the above methods of propagation, excepting for sowing seed of certain plants that can be reproduced in no other way, such as cotton, maize, sorghum, various beans, &c., usually grown on a field scale. It is then, in order to save time and labour in sowing by hand, often found more expedient to use a planting machine, and the example here illustrated (p. 48) is but one of those designed for the purpose. The action when in use for sowing cotton seed, its primary object, is explained on page 49, and the interchangeable parts required for planting maize (see p. 405), Kafir-corn or sorghum (see p. 424), pea-nuts (see p. 571), and various beans (see p. 457) are figured on page 50. The machine is shown at work on page 51.



The "Pilot" is made for planting rows at varying distances between 2 ft. 6 in. and 4 ft. apart. Primarily intended for planting cotton or maize it can also efficiently deal with Kafir-corn, beans, shelled peanuts (monkey or ground nuts) and similar seeds, when equipped with the necessary plates (see pp. 49 and 50).

COTTON PLANTING can be done by continuous sowing or "space planting."

For continuous sowing, the bottom of the seed hopper is provided with an agitating star wheel, which regularly carries the seed to a continuous sowing cotton picker wheel revolving in the opposite direction immediately beneath it. Around the picker wheel is a spring seed controller, which, whilst ensuring a constant flow of seeds being planted, prevents the possibility of seed, when covered with much lint, being drawn through and sown in lumps or bunches. By means of a sliding shutter, which is adjustable from the outside, the flow or amount of cotton seed sown can be conveniently regulated.



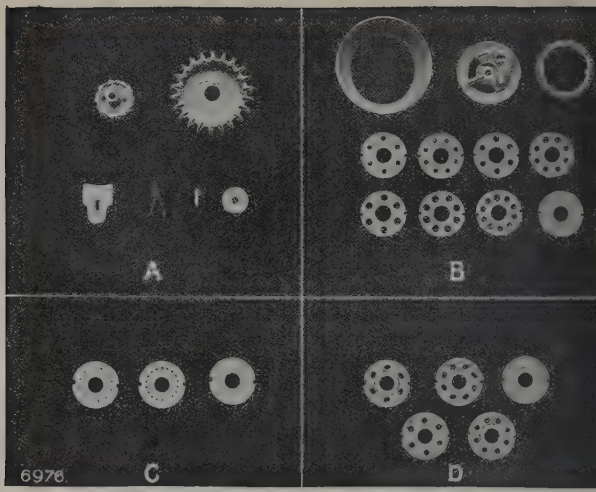
Bunching or Space Sowing of Cotton.—Spaced picker wheels can be fitted in place of the continuous sowing picker wheels. In using these, one, two or more cotton seeds can be planted in bunches and the bunches made at either of the following distances apart on the 2-row planter :—

Picker wheels with 3 spaces driven by high gear—space about 20 in. apart.

Picker wheels with 2 spaces driven by high gear—space about 30 in. apart.

Picker wheels with 3 spaces but driven by seven-tooth sprocket on sower spindle—space about 16 in. apart.

Picker wheels with 2 spaces but driven by seven-tooth sprocket on sower spindle—space about 25 in. apart.



A. Parts for Cotton Planting
(continuous sowing).

Cotton picker wheel. Agitating star wheel. Sliding shutter with bolt and wing nu
Spring seed controller with p.n. Agitating pin with nuts. Collar for same.

B. Parts for Maize Planting.

Sheet iron adapter bottom. Cut-off plate complete. Toothed ring for sower bottom.

Delivery or seed plates.			6 holes,	$\frac{1}{2}$	in. dia.
,,	,,	,,	8 ,,	$\frac{1}{2}$	in. ,,
,,	,,	,,	6 ,,	$\frac{5}{8}$	in. ,,
,,	,,	,,	8 ,,	$\frac{5}{8}$	in. ,,
,,	,,	,,	6 ,,	$\frac{3}{4}$	in. ,,
,,	,,	,,	8 ,,	$\frac{3}{4}$	in. ,,
,,	,,	,,	10 ,,	$\frac{3}{4}$	in. ,,
,,	,,	,,	Blank.		

C. Parts for Kafir-corn Planting, &c.

Delivery or seed plates.			12 holes,	$\frac{7}{16}$	in. dia.
,,	,,	,,	18 ,,	,,	,,
,,	,,	,,	Blank.		

D. Parts for Peanut and Bean Planting, &c.

Delivery or seed plates.			6 oval holes.		
,,	,,	,,	8 ,,	,,	
,,	,,	,,	6 holes,	$\frac{5}{8}$	in. dia.
,,	,,	,,	8 ,,	,,	,,
,,	,,	,,	Blank.		

N.B.—The parts shown for Kafir-corn or sorghum, and for beans and peanuts, are thos
required for converting planters already fitted for dealing with maize.

"PILOT" PLANTER AT WORK.

CHAPTER VI

CLIMATE

CLIMATE controls the growth of plants more than anything else, and one of the first questions the planter has to consider is whether the climate is suitable to the cultivation he intends to take up. The soil of parts of Holland may be suitable in every way to the growth of the sugar cane, and the soil of Jamaica to the growth of beet roots for sugar, but the climate, in both instances, prevents the possibility of success, if even any one were foolish enough to try it. And yet the Jamaican succeeds with the sugar cane, and the Dutchman makes sugar from his large crops of beet-roots, for the reason, simply, that the climate of Jamaica is adapted to the cane, and the climate of Holland to the beet.

Plants must be grown in suitable climates.

What climate is.

Climate implies the greater or less degree of *heat* and *light* and *moisture*—that is to say, the principal conditions that affect vegetation and render a country fit for the abode of man and animals. Climate is generally determined by latitude ; it is hottest at the equator, and it becomes colder the nearer we approach the poles. This general rule, however, is subject to exceptions, the chief one being elevation above the level of the sea. Near the equator there are mountains over 16,000 ft. high, the summits of which are covered with snow all the year round. Humboldt, the great German explorer, discovered that the thermometer fell one degree for every 343 feet of elevation, and thus in mountainous countries the climate really depends on the height

Latitude.

Elevation.

above the sea. This is very noticeable in small mountainous islands like Jamaica and Dominica, for whilst at the sea level the climate is hot and tropical, in the higher mountains it becomes cool and temperate. On the sea coast the mango and the sugar cane and the cocoa-nut flourish, whilst European fruits and vegetables cannot be cultivated; but in the heights of the mountains, the mango and cocoa-nut will not thrive, and yet European plants live and fruit and may even run wild, as in the case of the strawberry on the Jamaica cinchona plantations. Mountain climates.

Forests exert a very marked effect on climate, especially in the tropics, the dense foliage preventing the rays of the sun from reaching the earth, and thus the atmosphere is affected by cool vapours. When the forest is cleared away, however, and the land is brought into cultivation, the air becomes drier and warmer, and so does the soil also. A similar effect takes place when swampy and marshy land is drained and brought into cultivation. Forests. Cultivated lands drier and warmer.

When the atmosphere is loaded with clouds and vapours as is the case in all maritime countries, the climate is much more equable than in the interior of the continents. But lakes and marshes have a bad effect on climate; they give rise to fogs, especially at night, which chill the ground and render the place unhealthy.

Aspect has also an effect on climate, a northern and an eastern aspect being, as a rule, colder and moister than southerly and westerly ones; but, as aspect depends on the sun, in a mountainous country it is often affected by the lie of the land; ridges, alternating with valleys or ravines, causing a wide difference in the climate of places near to each other. In a narrow valley, one side, being mostly in the shade, may be cool and damp whilst the other side is warm and dry, and thus plant life would differ materially on either slope. Aspect. Valleys.

Exposed and windy situations have a different climate from sheltered places, although the soil and rainfall and aspect Exposure.

may be about the same ; but this, happily, in most instances the agriculturist may control, for shelter belts of trees will often convert an exposed and barren place into a thriving plantation.

Soil.

The soil has a great influence on climate, the temperature for instance of countries, whose surface is covered with sand, being much higher than the temperature of those in which it consists of clay. In the sandy districts of Egypt Bengal, Arabia, and other parts of the world where sandy deserts exist, the heat is intolerable in certain seasons of the year

Sandy districts usually hot.

Reference

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CHAPTER VII

MANURES

EXHAUSTION OF THE SOIL.—It has been shown that growing plants take up certain substances from the soil in a soluble condition, and these substances—which are called active constituents—exist in the soil in a small proportion only. If land be continually cropped, therefore, and no means be taken to restore the substances removed away in the crops, the soil becomes gradually *exhausted*, and the land loses its fruitfulness. In nature this does not happen, for, in forests, the constituents of the soil are returned by the decay of the leaves and branches and trunks which fall to the ground; and, on prairies and savannahs where wild animals roam, the return to the earth of the substances eaten as food, is continually going on, for the animals manure the land with their excrements in life, and with their bodies when they die.

Active constituents of soils.

Uncultivated land does not become exhausted.

The land must be regarded by the planter as a bank in which he has opened an account. If he continually draw cheques on the bank, and make no fresh deposit to meet the drain, he will sooner or later come to the end of his capital, and the same argument applies to the soil. In cacao and coffee cultivation in the West Indies, particularly on lands of peasant proprietors, one often sees the planter take away crops year after year, whilst he does next to nothing to make up for the heavy drain on the land; and, then, after a time, he finds he gets very small crops, and he thinks the

The land the planter's bank.

Bad cultivation.

fault lies with the trees, or that the soil is not adapted to the cultivation, whereas the fault is entirely his own, as he has gone on taking away from the soil without putting anything back.

Fertility to be restored by rest, as well as by good cultivation.

Exhaustion may, in certain instances, be partly prevented by *rest* and by *proper cultivation*. As, for instance, when the land is dug or ploughed up in order that the dormant constituents may be made active; or when the cropping is stopped by allowing the field to remain fallow. But this can be done only in those cases where cultivation such as sugar cane or corn is carried on; for cacao and coffee, and other such plants, are practically permanent, and so the land cannot be fallowed, and the crops cannot be stopped. It is in these cases, then, that manure and tillage operations are so useful and necessary.

THE ACTION OF MANURES.—The principal action of manures is to *restore the fertility* of an exhausted soil; to *enrich* a naturally poor soil; or to *prevent exhaustion* by giving back to the soil, in a suitable form, the various elements taken away in the valuable crops. Besides the action of adding plant food to the land, manures act

Chemical action of manures.

chemically on the organic and inorganic constituents of the soil; they render some of the dormant substances active, and in this way they *liberate plant food* that was, as it were, locked up in the land. A third, and an important action, is

Mechanical action.

a *mechanical one*, for manures improve the physical condition of the soil by making tenacious and heavy clay land lighter and more porous, and by binding together sandy soils and making them more capable of retaining moisture.

GENERAL AND SPECIAL MANURES.—Manures are usually divided into these two classes. *A general manure* is one that supplies to the soil all the consituents removed by

General manures the most valuable.

growing plants, not only from the soil but from the air. It contains, therefore, all the organic and inorganic elements found in the plant; and it is the most valuable kind of

manure that can be used by the planter. *Special manures*, which are sometimes called *artificial*, on the other hand, contain one or more of the necessary constituents of plant food, and they are used when it is found that these constituents have been removed from the soil by heavy cropping, or do not originally exist in the soil in sufficient quantity. Baron Liebig laid down what he styled the "*Law of Minimums*," by which he meant that the crops are governed by the *minimum* of one, or several, of the inorganic elements of plant food. A soil may contain in excess all the necessary constituents for plant growth except one, and if that one be supplied artificially the fertility of the soil is ensured. The application of a manure containing a plentiful supply of the one deficient substance, shows the principle of special or artificial manures; but it shows, also, the necessity of accurate knowledge of the soil and of plant life, in order to determine what ought to be the exact composition of the artificial manure the planter proposes to make use of. The indiscriminate and ignorant use of these manures frequently does permanent harm to the soil, without increasing the crops; and then they entail an outlay in money that brings no profit, and that often causes loss.

Liebig's law of manures.

Indiscriminate use of manures often does harm.

General Manures may be divided into three classes, namely—1. Farm yard manure. 2. Green crop manure. 3. Waste products.

Farm yard manure consists of litter (straw, cane trash, &c.) which has been trodden down by horses, cattle, pigs or sheep in stables, cowsheds, pigsties and pens, and mixed with the solid and fluid excrements of the animals. It is the most valuable manure that can be put on the land, for it enriches the soil more than any other substance can do, it exerts a beneficial chemical, as well as mechanical effect on the land, and no other manure is so lasting in its action. Its quality, and therefore its effect on the soil, varies greatly according to the animals producing it and the kind

Value of farm yard manures.

of food that is given to them. Young animals use most of their food to build up their bodies; and, consequently, the manure from them is not so valuable as that from fully grown ones. And animals that get rich food produce much richer manure than poorly fed ones. For instance, horses fed partly on corn or oats, or seed cake, give a more valuable manure than animals merely fed on grass; and, in England and elsewhere, cattle are often fed highly in order simply to enhance the value of their manure, and it is frequently found cheaper, in the end, to expend money in this way than in the purchase of artificial manures.

Well-fed animals give the best manure.

When farm yard manure is put in a heap it commences to ferment, this being caused by the rapid growth of myriads of low vegetable organisms, chiefly *Bacteria*, and this fermentation produces heat and causes important changes to take place in the manure, whereby it is rendered more fit for the formation of plant food. Sometimes an odour of ammonia is easily discovered, and this shows that the heap is *too dry* and that water should be thrown upon it. And when the heap is exposed and heavy rain falls on it, a stream of black liquid stuff will run out. This is very valuable and should not be lost. It ought to be collected and poured back on the heap or on to the soil, where its high fertilising action may be useful. This *liquid manure* contains ammonia and other organic substances, and hence its value as plant food. If possible, the dung heap should be kept under cover, and then there will be no chance of heavy rains washing away its valuable substance.

Fermentation.

Dung heap to be kept under cover.

Compost is a kind of farm yard manure composed of all the animal and vegetable refuse the planter can lay his hands on. Weeds, dead leaves, road and gutter scrapings, dead animals, kitchen waste, and any other thing of the kind, are heaped up together and allowed to rot, when a valuable manure will be formed. Its value may be increased by pouring some of the liquid manure over it, and by turning it sometimes, so as to assist the fermentation by allowing

Value of compost.

air to enter. The addition of a small quantity of lime stirred into a compost heap improves the quality of the manure immensely, as it assists in forming nitre (or nitrate of potash), a very important fertilizing substance—which is too expensive, however, to be much used as an artificial manure. Nitre.

Synthetic Farm Yard Manure can now be prepared from straw and various kinds of waste vegetable matter, by a process which is the outcome of several years' experimental study of cellulose-rotting *Bacteria*. The method has been commercialized, and the product named *Adco Manure*. The discovery is of importance to Agriculture in all parts of the world, especially in the Tropics, the stems or straw of rice, maize, sorghum, and also the rank vegetation—such as "alang-alang" grass (*Imperata cylindrica*)—usually so plentiful in a plantation, being convertible by a simple treatment into a source of plant food, quickly ready for use. The refuse is collected into heaps, thoroughly wetted and mixed with the right proportion of *Adco* powder or re-agent, which causes rapid fermentation, only occasional turning of the heaps, to admit air, being required. Complete rotting may be effected in from two to six months. It is claimed that one cwt. of the powder makes from two to three tons of manure. Waste vegetable matter used to make *Adco* manure.

Green Crop Manuring.—By this term is understood the digging or ploughing into the land of growing crops in order that the roots, stems and leaves may decay in the soil and thus improve its condition. It does this by giving to it humus and, in the case of leguminous plants, by increasing its nitrogen content, since the latter plants, such as clover, peas and beans, have the property of absorbing nitrogen from the atmosphere, so that, when dug in, they return to the soil more nitrogenous material than they took from it. This system is extremely well suited to light soils. It also has a good effect where the soil is heavy and retentive. In a general way green crop manuring has been tried with success in many tropical countries. "Pigeon peas" (*Cajanus*

indicus), "Bengal beans" (*Mucuna aterrima*) and "velvet beans" (*Mucuna Deeringiana*) amongst other leguminous plants have been generally recommended. "Sann" or "Sunn" hemp (*Crotalaria juncea*) has been found effective in India, where this crop is largely grown as a fibre plant (see p. 531). When sown on well-prepared ground it can be ploughed in after about a month's or six weeks' growth. The advantage of green manuring with *Crotalaria juncea* in tobacco cultivation is illustrated on page 61, in comparison with the use of old tobacco stems as a manure for the same crop.

Leguminous plants as green crop manure.

Sea-weed, fern foliage and all other similar vegetable materials that may be obtainable, make excellent green crop manures, and those planters whose estates are situated near to forests, or to a shore strewn with sea-weed, should not neglect the opportunities thereby offered, of a plentiful and cheap supply of manure that contains many if not most of the elements necessary for the food of cultivated plants.

SPECIAL MANURES are often called artificial, not because they are all made artificially, but in order to distinguish them from farm yard or natural manure. There are many kinds of special manures, but they may be all referred to four principal classes, namely :—1. Nitrogenous manures. 2. Phosphatic manures. 3. Calcareous manures. 4. Potash manures. If farm yard manures could be obtained by all planters in sufficient quantity for their lands, there would be no necessity at all for special manures ; but it is very rarely the case that enough general manure can be obtained on an estate, and the successful agriculturist is forced to fall back on the various special manures that chemical science has shown to contain the elements of fertility wanting in his soil.

Four classes of special manures.

NITROGENOUS MANURES, as their name implies, are rich in nitrogen, which, as we have seen, is an important plant food

GREEN MANURING, SHOWING ADVANTAGE OF MANURING TOBACCO WITH "SUNN HEMP" (*Crotalaria juncea*). In the two plots shown, the left was green manured with Sunn hemp and the right with old tobacco leaves and stems; plants photographed about fifty days after transplanting seedlings.

[*From "Memoir Dept. Agric. India," by A. Howard and C. L. Howard, iii, April,* 1910.

ALANG-ALANG (*Imperata arundinacea*).

One of the rankest growing grasses in Tropical Africa and Asia. "Changkolling," or hoeing out by the roots, in Malaya.

carried to the earth in the form of the ammonia and nitric acid of the atmosphere. As nitrogenous matters exist but sparingly in most soils, they are easily exhausted when crops are continually reaped off the land; and hence the necessity for restoring them in the form of special manure, if the soil is to be kept fertile. The most important and the best known of the nitrogenous manures is *Guano*, which, as a fertiliser of the soil, ranks next to farm yard manure. It is the dry dung of sea-birds, found principally on the coast and the adjacent islands of Peru, and it may contain up to 12 per cent. of *nitrogen*. As rain rarely or never falls in these places, the dung has retained its soluble nitrogenous constituents and these give value to the manure. Some of the best guano deposits have become exhausted, and so the manure now supplied under that name is very often of an inferior quality, hence the necessity of particular care in purchasing the article; some buyers, indeed, exercise so much caution in the matter as to require a chemical analysis of the manure they are about to purchase. Guanos contain phosphates of lime and magnesia, and sometimes these substances are in such large proportions as to render the manure partly a phosphatic one. Rain and sea-water dissolve out the nitrogenous substance, and when guano is taken from places subject to these influences it is found that the nitrogenous matters are low in quantity and that the phosphates are abundant. Consequently there are two kinds of guano one remarkable for its nitrogenous substances which is called nitrogenous guano, and the other called phosphatic guano on account of the abundance of phosphates in it.

Nitrogenous matters in soil soon exhausted.

Composition of guano.

Two kinds of guano.

The principal other nitrogenous manures are *sulphate of ammonia*, and *nitrate of soda*. They are richer in nitrogen than even guano; and, as they are very soluble, they are used to stimulate, or to whip, as it were, the soil into doing more work; they are on this account sometimes called "stimulants" or "whips." Their effect is immediate and marked. In a few days after application of the manure,

Soil stimulants.

the foliage becomes greener, abundance of fresh leaves are thrown out, and the succeeding crop is large. Sulphate of ammonia was formerly one of the "waste products" of the gas manufactories. Nitrate of soda, or "Chili saltpetre" is a white salt-like substance found in enormous beds, sometimes eight feet thick, in the rainless parts of Peru and Chili.

PHOSPHATIC MANURES.—Phosphorus, as combined phosphoric acid, is an important plant food, and it is classed as one of the secondary organic elements. It cannot be obtained from the air; and, as it exists in the soil usually in very small quantities, it is one of those substances that are liable to be exhausted by continuous cropping, and thus it must be supplied in the form of a manure. It is present in all general manures, and some of the special manures contain it in large quantities and hence they are called phosphatic manures. Phosphorus is a very important constituent of the bones of animals and the milk of cows, and when cattle are grazed on pasture land for any length of time they exhaust the phosphoric acid in the soil by taking it up in the grass, and by "fixing" it in their own bodies. This is the principal reason that pastures become "poor" or "worn out" or "used up," and it has been found by experience that the application of phosphatic manures to a worn-out pasture will soon restore it to a luxuriant condition. The principal phosphatic manures are *bones*, *superphosphates*, and *reduced phosphates*.

Phosphates in the soil liable to exhaustion.

Worn-out pastures.

Bones contain about half their own weight of phosphate of lime, all of which has been taken by animals from the soil in their food. For a long time past bones have been used as manure. They were broken into small pieces with hammers and spread over the land, and this was called "boning" the soil. But bones do not readily crumble away, and so they were ground to powder, and in this way they acted quickly. It was found afterwards that they would ferment if moistened with water and kept in a heap exposed to the air; and, as the fermentation causes the bone to decompose, or break

"Boning" land.

Fermentation of bones.

lown into its various constituents, this system was a marked mprovement. Baron Liebig, however, to whom agricul- ural science owes so much, found out a cheap and rapid vay to prepare the bones for manure. He acted on them by sulphuric acid, producing a dissolved bone manure, and n this condition the phosphate of lime becomes quite soluble nd ready to be used as a plant food.

Mineral Phosphates. — The demand for phosphatic nanures becomes so great, owing to their important action n the soil, that the supply of bones could not keep up with he demand, and other sources of phosphates had to be ooked for. Fortunately, large quantities of fossils of ex- inct organisms, and petrified excrements containing phos- hates, known as *coprolites*, were found in the Eastern counties of England, and in various parts of the continent f Europe, and they were soon utilized for phosphatic nanures. Besides coprolites, deposits of mineral matters ich in phosphates have been discovered in practically in- exhaustible quantities in various parts of Europe and Ame- ica. In the West Indies, mineral phosphates are mined in he Islands of Sombrero, Redonda, St. Martin, Aruba and Navassa. Except in the case of the Redonda deposits, the hosphoric acid in the mineral phosphates is combined in arious proportions with the metal calcium, and in the Re- londa mineral the acid is combined with alumina, forming hosphate of alumina. The mineral phosphates are usually f a very hard rock-like character, and before being used hey are ground to powder ; but, as the phosphates in them re, for the most part, in an insoluble condition, and, there- ore, not easily taken up by the plants, it has been found ecessary to dissolve them in sulphuric acid so as to im- prove their manurial value.

Phosphatic fossils.

West Indian phosphates.

Superphosphates.—The discovery of the way to convert he insoluble phosphate of lime, or calcium, of bones and minerals into the soluble form has been of immense service o scientific agriculture. The insoluble phosphate is com-

Chemistry of the phosphates.

posed of three equivalents of lime in combination with phosphoric acid, and it is called *tribasic*, or *tricalcic phosphate* because the base of the compound—the lime, is treble. It may be thus expressed:—

$$\text{Phosphoric acid} \left\{ \begin{array}{l} \text{Lime.} \\ \text{Lime.} \\ \text{Lime.} \end{array} \right.$$

If bones be simply broken up and put into the soil, after a time the tribasic phosphate becomes converted in a sparingly soluble dibasic phosphate by the action of carbonic acid and water. Thus—

$$\left. \begin{array}{l} \text{Phosphoric acid} \left\{ \begin{array}{l} \text{Lime.} \\ \text{Lime.} \\ \text{Lime.} \end{array} \right. \\ \text{Carbonic acid.} \\ \text{Water.} \end{array} \right\} \text{become} \left\{ \begin{array}{l} \text{Phosphoric acid} \left\{ \begin{array}{l} \text{Lime.} \\ \text{Water.} \\ \text{Lime.} \end{array} \right. \\ \text{Carbonic acid and Lime.} \\ \text{(or Carbonate of lime.)} \end{array} \right.$$

But when sulphuric acid is poured on tribasic phosphate, a perfectly soluble *monobasic phosphate*, and sulphate of calcium (or gypsum), are formed. The chemical reaction is easily understood from the following equation.

$$\left. \begin{array}{l} \text{Phosphoric acid} \left\{ \begin{array}{l} \text{Lime.} \\ \text{Lime.} \\ \text{Lime.} \end{array} \right. \\ \text{Sulphuric acid.} \end{array} \right\} \text{become} \left\{ \begin{array}{l} \text{Phosphoric acid} \left\{ \begin{array}{l} \text{Water.} \\ \text{Lime.} \\ \text{Water.} \end{array} \right. \\ \text{Sulphate of calcium.} \end{array} \right.$$

This soluble monobasic phosphate is called a *Superphosphate* because the proportion of phosphoric acid to the lime is above what it is in the other phosphates.

Objection to superphosphates.

Reduced Phosphates.—Superphosphates are very soluble and it has been found, for this reason, that they are unsuitable for some soils, as they are too easily washed out by rains, and it has been discovered also that they are too acid for plant food, and, therefore, useless until they have been so acted on by other substances in the soils as to be available for the use of the plant. In calcareous soils the super-

phosphates are at once acted on by the lime, and their acidity is reduced, and they become dibasic phosphates— which is the best form for plant life; but in soils where there is not much lime this process cannot take place, and agricultural chemists have made *reduced phosphates*, which are simply these dibasic phosphates of lime.

Dibasic phosphates the best for the soil.

Thomas-Gilchrist Slag, or *Basic Slag*, is a valuable phosphatic manure made from slag—a substance which was formerly a waste product given off in the process of purifying or smelting iron and steel. This slag is a black blistered material that collects in quantities on the surface of the molten iron. It contains a large proportion of phosphate of lime, as well as metallic iron and its oxides, silica, magnesia, and oxide of manganese. The manure called usually "Thomas Phosphate Powder" is made by separating the metallic iron from the slag, and then reducing the remaining mass to a fine powder—in which form it is applied to the soils as other manures. It has been used with success on sugar plantations in British Guiana and elsewhere in the tropics, and it is employed extensively in Europe: but, as it contains a large proportion of iron, it is not considered to be suitable for ferruginous soils.

Formerly a waste product.

Its composition.

A valuable manure for soils that do not contain much iron.

CALCAREOUS MANURES.—Lime is an important constituent of all plants; and, although it is present in abundance in most soils, it is deficient in some. There are soils also, such as stiff, heavy clays, where the application of lime has a beneficial effect by its chemical and mechanical action. It renders insoluble substances soluble, and it causes the cold, heavy clay to become warmer, and more friable and porous. Lime is applied to the soil in its ordinary state, and it is then called by the planter "raw lime," or in a crude state as chalk, marl, shells—which are composed mainly of carbonate of lime, and as gypsum or sulphate of lime.

Lime acts chemically and mechanically on the soil.

When coral, or shells, or limestone, are heated in a kiln, the carbonic acid is driven off and pure lime or "quick-

lime" is left. Cold water poured on quick-lime causes it to swell up, with the evolution of much heat, and then it falls down into a white powdery stuff which is much more bulky than the quick-lime was. This powder is called slaked-lime, and it has not such a burning effect as quick- or unslaked-lime. Both forms are used as manure, the unslaked-lime being applied to vegetable soils containing deleterious vegetable acids. It neutralises the acids, and it forms useful compounds in the soil. Chalk, broken shells and limestone, and also marly and calcareous earths, are applied to soils in which there is a deficiency of lime. All these manures—for if one soil be added to another to increase the fertility it is still called a manure—should be kept near the surface, and not be ploughed deeply in, as lime sinks into the soil, and has a tendency, therefore, to run away from the roots of the plants.

Slaked-lime.

Lime to be applied to surface of soils.

Gypsum, or sulphate of lime, is often used as a manure. It is an ingredient of all superphosphates, and the phosphatic manures are to a certain extent calcareous ones. Gypsum, which consists of lime, sulphuric acid and water, is found in a native state in various parts of the world. Deprived of the water it forms the well-known "plaster-of-Paris." Formerly gypsum was added to dung-heaps, and spread on the floors of stables, &c., as it was believed to have the power of "fixing the ammonia," that is, preventing it from passing away in the form of vapour; but now it is applied at once to the land, and it is found to be especially useful as a manure for potato crops.

Uses of gypsum.

POTASH MANURES.—Potash enters largely into the inorganic constituents of plants, as is shown by its being one of the chief of the substances found in the ashes. It is usually abundant in the soil, and it is only after heavy cropping that it becomes necessary to make up for its loss by the application of a potash manure. As it is contained in quantity in all plants, it is returned to the soil by the decay of weeds

and the leaves of trees and bushes. One of the chief reasons of the value of a general manure is the fact that potash is an important constituent of it. When a potash manure was required it used to be supplied as wood-ashes; but, in parts of Germany, large beds of potash salts, known as *kainit*, have been discovered, and they have been dug out and used as manure. Kainit contains salts of magnesium and sodium besides those of potassium. In most parts of the West Indies, however, potash manures are unnecessary, as the potash can be obtained from the abundance of refuse vegetable matters found everywhere. Ashes of plants, decayed weeds, and green crop manures will supply all the potash necessary for the growth of West Indian crops, except in cases—as on some sugar-cane estates—where the same crops have been raised for many years from the same soil, and where vegetable manures are obtained with difficulty.

Importance of potash manures.

Composition of kainit.

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CHAPTER VIII

ROTATION OF CROPS

Active and dormant constituents of soils.

It has been shown in the preceding pages that only a small portion of the soil can be dissolved out in water, and that this soluble portion is the only available one for plant food. Other and much larger portions are, however, in a dormant condition, and are, therefore, after a time, by the action of water and air, capable of being eaten up by the plant. But, when successive crops from one kind of plant are taken off the soil, the alteration of the dormant constituents cannot keep pace with the drain caused by the growing plants—which then become weak, sickly and unproductive. By resting the land or allowing it to *fallow* for a time, some of the dormant constituents become active, and fertility is restored ; but, in certain cases where not much land is available, the loss of a year's crop is a very serious matter, and means have been devised to overcome the difficulty. One of these means is the application of manure. But then manure costs money, and it may not always be possible to obtain it. So the second system, called *rotation of crops*, is employed with success in many cultivations.

Fertility sometimes restored to soils by fallowing.

Different plants require food in different proportions.

The ashes of all plants are not the same in composition ; and, therefore, plant food is not always required in the same proportions. Some plants, as shown by their ashes, require a large proportion of potash and phosphoric acid ; others consume much silica and require less potash and phosphoric

cid; and others, again, want a good deal of lime and magesia, and less of the other inorganic elements. For instance, urnips take up from the soil five times as much potash as vheat; barley takes up twenty-six times as much silica as vheat; and clover requires eight times as much lime and nagnesia as wheat, and only one-sixteenth the quantity of ilica. If, therefore, turnips be grown on the land one year, nd barley, clover, and wheat be grown on the same land for hree succeeding years, it is found that the soil in the four ears gives a much greater return, with less injury to the and than if one of the crops were raised every year for our years. This is the system usually employed in Norfolk n England, and it is called the Norfolk course of rotation. In some parts of the world the soil is so deep and rich that, with proper tillage, the same crops can be grown on it for numbers of years, without the application of any manure; but, even with this extra fertile soil, the time comes when exhaustion takes place, and in certain districts of the United States of America the land which was once exceedingly fertile has been almost ruined by constantly taking off the same crops. It is a principle in rotation that two grain crops should not succeed each other, but be separated by root or fodder crops. Thus it would be a very bad system to take maize crops off the same land for two years running; but, if tanias or yams be planted the first year, maize the second, sweet potatoes the third, and castor oil or some such crop the fourth, a very good rotation would be established. Unfortunately, in the West Indies, very little attention has been directed to working out a proper system of rotation, as has been done in Europe and North America; and it is impossible, therefore, to lay down any precise rules for the guidance of all planters. But every one can make experiments for himself, and it is not necessary, in the way of experiment, to plant more than a small portion of land, say 50 or 100 feet square. A good planter will be always experimenting in one way or another, in order, practically, to find out

Norfolk system of rotation.

A suggested West Indian course of rotation.

The importance of experiments.

the value of manures on his land, or the results of rotation on his crops, &c. Indeed it is mainly by experiments, conducted by scientific men and farmers or planters, that agriculture has become what it is to-day. In the tropics there is much room for improvement and discovery: and every planter, no matter how humble may be his position, is capable of making such discoveries by experiment as may be of material benefit to his neighbours, and perhaps to the world at large. Some of the most wonderful scientific discoveries of all ages have been made by humble workers, without the aid of any elaborate apparatus.

Improvements wanted in the tropics.

Resting of various layers of the soil.

An important effect of rotation is the resting of the various layers of the soil. For instance, maize sends down its roots deep into the ground, and so derives much of its sustenance from the sub-soil. Potatoes and tanias, on the other hand, are surface feeders, and they eat up the soluble constituents of the surface soils, which were, to a great extent, left alone by the roots of the maize.

Mechanical effect on soils.

Rotation also exerts a beneficial, mechanical effect on the soil in two ways. Firstly, in the preparation of the land each year for the different crops, the turning over of the soil causes its exposure to the atmosphere, and the dormant constituents are thereby acted upon by the oxygen of the air, with the result that the active and soluble constituents are increased in quantity. Secondly, the roots of the former crops, rotting in the soil, cause channels for the entrance of water and air in all directions, and thus the soil is made more porous, and the atmosphere is able to exert its beneficial effects not only on the surface but even in the sub-soil.

Rotation prevents blights.

In addition to all these advantages, a proper system of rotation prevents blights and keeps away destructive insects that confine their depredations to particular plants. When a crop intervenes on which these insects cannot feed they die of starvation, and are in this way got rid of. The same applies to vegetable blights, which are usually in the form of extremely minute plants belonging to the order of moulds or

mushrooms. It is generally noticed that plants cultivated on the same land for many succeeding years are prone to be injured by vegetable blights and insect pests. In nature, a diversity of plants is found on the same soil; and, when natural laws are much interfered with, there is the probability of disastrous consequences ensuing.

Danger of interfering with the laws of nature.

It is, however, not always convenient to adopt a system of rotation in the even order of the home fields in tropical countries, where there may be permanent crops such as coffee, cocoa, rubber, &c., or some annual crops which require to be grown under special conditions. It is then desirable to fall back on manuring to keep the ground in good tilth. The effect of rotation may in a large measure be gained by a mixed cultivation, as, for instance, "cow peas" (*Vigna Catiang*) and "Sudan grass" (*Sorghum sudanense*) for fodder; or "velvet bean" (*Mucuna Deeringiana*) with one of the taller-growing sorghums—"Kafir-corn" (*Sorghum Caffrorum*) or "sugar sorghum" (*S. saccharatum*)—the stems of the sorghum plants supporting the beans until both are cut for green forage. Other suitable mixtures will often suggest themselves to meet favourable situations.

Rotation by mixed cultivation.

CHAPTER IX

DRAINAGE

IT has been shown in the preceding pages, that rain, apart from its action in dissolving the soluble substances of the soil, has a markedly beneficial effect in other ways. In the first place it washes down the carbonic acid, ammonia and nitric acid of the atmosphere, and brings them to the roots of the plants. In the second place, the passage of the rain through the soil causes air to follow it, so as to fill up the vacant spaces left by the water as it descends to the sub-soil.

The effect of rain.

A porous soil contains little spaces and channels between the earthy particles, for the soil is not properly solid, but consists of innumerable little pieces of wasted rock which do not fit into each other, but only touch at certain parts, thereby leaving open spaces in all directions. Now, when the soil is dry, these spaces are filled with air; and, when much rain falls, they become filled with water. But, as the water drains down into the lower layers of the soil, fresh air is drawn in again—for the spaces cannot exist with nothing in them. This explains what is meant by the *porosity* of a soil, and it shows how advantageous it is for the planter to change a heavy, compact, and sodden clay soil into a porous one.

The soil is not solid.

Porous soil.

Another physical property of soil is that known as *capillarity*, and which has been considered in Chapter III. Capillarity, or capillary attraction, is due to the same cause as porosity; but, in the case of capillarity, the particles of

ıe soil are finer and more closely packed together, and each article is surrounded by a thin layer of water in which are issolved substances useful for the nourishment of plants. Capillary attraction may be easily demonstrated by taking vo small sheets of glass, and applying their faces so close ogether as to make them almost touch. If they be then ipped into water, it will run up for a distance on the inner urfaces of the two glasses. This action is capillary attraction, and to it is due the fact that all the water does not run ut of a well-drained soil, but a portion remains to benefit egetation.

Fine particles of soil surrounded by a thin layer of water.

When the rain, which falls on the earth, sinks down into he soil, and does not leave it sodden or saturated with ıoisture, the land is naturally drained; but in some nstances there is an obstacle to the water running off, it emains in the soil, it keeps the soil cold, it prevents the ntry of the atmosphere, thus putting a stop to the change f the dormant into the active constituents, it becomes after time impregnated with vegetable acids that are injurious o plant life, and it causes the roots to damp or rot off. The eason that a damp soil is a cold one, is explained in several vays. In the first place the water is colder than the urrounding air, and the presence of the water prevents the ir from entering in to warm the soil. Then again, the land s rendered cold by the evaporation of the water. Every one nows that water left in a saucer, in the atmosphere, will radually pass off into vapour—in fact, it will dry up. But he conversion of water into vapour carries off a good deal f heat, and this is the principle made use of in water-coolers nd goblets. These are made of porous earthenware hrough which the water gradually percolates and is then vaporated from the outside surface. This causes a great bstraction of heat, thereby making the water in the goblet, nd the goblet itself, much cooler than the surrounding air. This is also what takes place in soils sodden with moisture, nd the object of drainage is to remove the surplus water

Natural drainage.

Sour or acid soils.

Damp soils always cold.

Evaporation abstracts heat.

Drainage causes fertility.

from the soil, and thus to make it warmer, to restore its porosity, to make it sweeter by the removal or alteration o the vegetable acids, and, in short, to make it more fertile.

Most of the land in the West Indian Islands being of a hilly nature, it may be easily drained by digging deep, open trenches so as to carry off the surplus water to the lowes part of the estate, or to a stream in the vicinity. The depth of the main trench or ditch will depend on the nature of the soil, the amount of water and the lay o the land, but it should not be less than three or four feet, as the roots of many cultivated plants go deep into the soil, and it does them much harm to be kept in standing water.

A more expensive way is to make covered drains, which i done in the following manner :—The trench should be dug wide at the top ; and at the bottom, which should be smooth and sloped gradually, it must not be wider than it can b made without the sides falling in. Along the bottom are placed drainage pipes or tiles. The latter are simply flat earthenware tiles curved in a semi-circular manner, and they form an arch to allow the water to run freely under neath and to support the earth with which the trench i filled up. Small stones and pebbles should first be placed over the tiles ; or, if they cannot be got, brushwood o straw or cane trash may be used ; surface earth, but not the clay from the trench, is then filled in over this, and the drain is complete. The outlet must be kept clear, and provided this be done there is very little chance of the drain becoming choked. Another way is to fill the trench nearly to the surface with stones, large ones being placed at the bottom and smaller ones on top.

Drainage pipes and tiles.

Outlet of drain to be kept clear.

Soil must not be over-drained.

Of course in draining land, as in all other agricultural operations, experiments will often teach useful lessons. By deepening drains, or by running cross drains into them, the fertility of the land may be much increased, but care must be taken not to overdrain a soil. The object of drainage is no

o make the land absolutely dry, but to prevent the stagna-
ion of water in it—that is, to make the rain water pass
lowly through the soil, allowing it to leave in its passage
ufficient moisture to keep the soil moderately damp below
ne surface. In light, porous soils, drainage operations must
ot be carried so far as in heavy, clay ones ; indeed the poro-
ity of the soil and its capability of holding moisture, will
lways indicate to an intelligent person acquainted with the
rinciples of agriculture, what amount of drainage is neces-
ary for his lands.

CHAPTER X

IRRIGATION

Objects of irrigation.

Drainage means the removal of water from land where i exists in too large a quantity. *Irrigation* means the reverse namely, the application of water to land where it does no exist at all, or where its quantity in the soil may be increase so as to benefit vegetation. A good deal has been sai about the necessity of water to fit the soluble part of th soil for plant food. Without water, therefore, plants canno

Arid regions.

live, and in the large, rainless tracts of land in Peru, Bolivi and Chili, and other parts of the world, there is no vege tation, *except in those places to which water has been carrie by irrigation.* Water may be conveyed to the land b canals, or pipes or spouts, from rivers, or lakes, or pond or it may be pumped up from wells and thence distribute over the soil.

The art of irrigation comprises two essential particular namely, to give a supply of water to growing plants ; an at the same time, to prevent the supply being so great as t cause the soil to remain sodden with moisture. If, ther

Provision must be made to get rid of surplus water.

fore, canals and trenches be made to carry water, to irriga the soil, particular care must be taken to provide canals f taking away the water after it has passed through the lan In some cases, the water is simply conducted through th land by the canals, the soil obtaining its supply by the wat percolating through the porous earth. Another system is have a series of transverse trenches on the sloping lan

Irrigation trenches.

The water is conducted to the upper trench or canal, and overflows and runs along the surface, to collect in time the second trench. After the second trench is full, the wat in it overflows and runs down to the third trench, and th goes on in a similar manner until the water from the last lowest trench is carried away to the river or to some low

level, where it will do no harm. This is called catch-work irrigation. In some countries, where large rivers run through low lying land, as in the case of the river Nile in Egypt, and the river Ganges in India, the river itself is allowed to run over the land when its waters are swollen and full of rich mud. The waters are allowed to remain on the land whilst the mud settles, and in this way the fertility of the soil is enormously increased. The number of feet that the waters of the Nile rise above the lowest level, is a sure index of the crops to be expected in Egypt. A low Nile means short crops and distress amongst the people, whereas a high Nile indicates large crops and prosperity. In India too, a low Ganges means, sometimes, terrible famine in the lands it is unable to irrigate; and the great works of irrigation carried on by the government of India, have happily prevented, in many instances, the occurrence of famines, and turned poor districts with their miserable and sickly inhabitants, into highly cultivated lands peopled with a healthy and prosperous population. In Egypt irrigation works (since 1902) have now also relieved the uncertainty of crops. Regulation dams at Asyût and Aswân with suitably placed reservoirs and high-level canals admit of irrigation over a large area, when the Nile floods subside and the normal volume of the river fails to supply the needs of agriculture.

Overflow of rivers.

The rising of the Nile.

The irrigation works in India, and in Egypt. Their beneficial effects.

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CHAPTER XI

TILLAGE OPERATIONS

The advantages of tillage.

If the soil were allowed to remain without any preparation of tillage, its upper layers would become so hard and compact that the seeds sown could not germinate; and, if seedlings of coffee or cacao were planted out, the young and delicate roots would not be able to penetrate the hard soil, and the plants would die. Tillage operations, which are really the breaking up and stirring of the soil, prevent all this, for they render the soil loose and friable, so that the seeds can easily germinate, and the young roots can push themselves through the soil with facility. But, besides this important effect, tillage acts in other ways on the soil. By digging and ploughing and by the various other operations the earth is turned over and exposed to the action of the atmosphere, by which means, insoluble portions of the soil are rendered soluble and thereby become available for plant food. Another effect of tillage is to render the soil more open and porous and thus to facilitate the passage of water through it. And lastly, it is the means employed by the planter for getting rid of the weeds which are ever ready to eat up the food that ought to be kept for his crops. A properly tilled soil is therefore free from weeds open and porous; and a badly tilled or untilled soil is hard on the surface, compact, and full of weeds; and if it have any cultivation on it, the plants are poor and the crops are small. If a clean soil, after heavy rain, settle down with a hard surface, the tillage has been

Tillage increases the soluble constituents of the soil,

renders the soil porous,

and destroys weeds.

Good and bad tillage.

bad, but if the rain sink into the soil without forming a "crust" it is a good indication of proper tillage.

The deeper the soil is tilled, the better it is for the plants growing on it, as the atmosphere descends deeper, and thus acts on more soil, and prepares more plant food. This accounts for the advantages derived from sub-soil ploughing and from the *holing* of the land; which, as we shall see in the second part of this book, is the proper way to prepare the soil for cacao, coffee and other plants put in at a considerable distance from each other.

Deep tillage the best.

The sub-soil to be turned up.

Tillage operations are of two kinds; namely, those performed by man himself with manual implements, and those performed with implements worked by horses or cattle, or by steam.

Manual and implemental husbandry.

The implements of manual husbandry are,—(1) the *cutlass*, (2), the *rake*, (3) the *hoe*, (4) the *spade*, (5) the *fork*, (6) the *dungfork*, (7) the *pickaxe*, and (8) the *digger* or *earthchisel*.

THE CUTLASS is a long, broad, heavy knife with a short handle. It is one of the most useful implements of the West Indian labourer. By its means bushes are cut down, trees lopped and the land weeded to a certain extent. On steep hill sides, where the heavy rains would wash down the soil if the land were hoed up, the cutlass is used to clear away the weeds by cutting them off just at their roots. On an emergency, too, the cutlass may be used for digging small holes, and for pruning off the large branches of trees. Some men are so expert with this implement that they are able, with one swift sweep, to cut off a big branch of a tree, and the cut is as clean as with a saw. The *machete* is a similar tool in use in West Africa and other countries.

Utility of the cutlass.

THE RAKE is a bar of iron along which iron teeth are arranged, as are the teeth of a comb. It is fixed on a long handle which is set at right angles to the teeth. Rakes are made of various sizes, and are used for raking up weeds and

rubbish, and for breaking up the soil after it has been dug up and turned over.

THE HOE is also an implement used very extensively in the West Indies. It varies both in size and shape, but the one most in use is a plate of iron seven inches long and about six inches broad, sharpened at the cutting edge, and fixed, at somewhat less than a right angle, to a handle about four feet long. It is used for digging, for turning over the soil, for weeding, and for drawing up earth to the roots of plants. A strong man can do a great deal of work with a hoe in the course of a day, and in places where a plough cannot be used it is simply an invaluable instrument for tillage operations.

Utility of the hoe.

THE SPADE is a flat blade of iron fixed to a handle about two feet nine inches long. At the upper edge of the blade, close to the insertion of the handle, a narrow piece of strong iron—called the *tread*—is fixed so as to allow the foot of the operator to push the spade into the ground. The spade is not much used in the West Indies, but it is a very valuable implement, and it really does better work than the ordinary plough. The soil is dug about eight or nine inches deep, and the spadeful of earth is thrown forward, being turned as it is thrown, so as to leave the under surface of the soil uppermost.

The spade does better work than the plough.

THE FORK is shaped somewhat like a spade, except that instead of a blade it has from three to five strong pointed iron prongs, called *tines*, at least an inch in width. It is a most useful implement, and for digging operations it is by many persons preferred to the spade, inasmuch as it is easier to use, it pulverizes the soil better, it does not so readily cut or injure the roots of cultivated plants, and in most soils the clods of earth can be turned over as easily with the fork as with the spade. It is used also for stirring up the earth around the roots of plants, and for "forking in" farm-yard manure and leaf moulds.

The fork preferred to the spade.

THE DUNG FORK is made on the same principle as the cultivating fork, except that the tines, which are from two to six in number, are slighter in structure, more curved and of a rounder form. It is the only implement that can be used with facility in the loading, turning over, mixing and spreading of farm-yard manure, stable litter and such like substances. Being light, although strong in construction, it is not difficult to manage, and the sharp and thin tines easily penetrate compact farm-yard manure without the necessity of exerting much force. Utility of the dung fork.

THE PICKAXE is a strong, slightly curved bar of iron tipped with steel, into the middle of which a wooden handle is fixed so that the concavity of the curve is towards the operator. One end of the pickaxe is usually pointed, and the other end flattened out and sharpened like an axe. The handle must be of strong, hard wood of a pliable nature, for a brittle one would soon break in use. The pickaxe is used as a powerful double lever; and as an implement to break up hard soil, and to cut the roots of trees in the ground. In digging holes, and in throwing down banks, the pickaxe is almost indispensable. The handle to be carefully made. A double lever.

THE DIGGER or EARTH CHISEL is a very useful implement for holing the ground for planting cacao, lime, orange, coffee and other young trees. It is a strong, heavy chisel, about four inches broad, fixed into a hard-wood handle about three feet long. In digging deep holes, where the pickaxe and hoe cannot be used, the digger is most serviceable. The digger useful for holing land.

The principal implements worked by cattle or horses are *ploughs, cultivators, harrows* and *rollers*. They all do the same kind of work as the manual implements; but, as they do the work much faster and cheaper, they are of course employed in cases where extensive tilling operations are to be carried out.

THE PLOUGH is an implement used to perform the work of the spade. It consists of a curved blade of iron—the *mould-board* or *turn furrow*, terminating in a strong steel extremity—the *ploughshare*, and so arranged that it can be dragged through the earth by cattle, and guided by a man. In front of the ploughshare is a strong, knife-like, cutting instrument called the *coulter*, which cuts the earth and thus allows the free entry of the ploughshare, the mould-board then turns over the slice of earth to one side, thereby burying the weeds and exposing the under surface of the soil to the sun and air. The disc-plough is a modern development in which the share and mould-board or breast is replaced by a large steel concave disc—28, 26 or 24 inches in diameter. Some ploughs are made to run along the furrows made by the ordinary plough, in order to break up the subsoil, for it has been found that continual ploughing of the land to one uniform depth causes the subsoil to become so hardened and compact that the roots of plants cannot easily penetrate it. This compact layer is called a *ploughpan*, and one of the objects of the *subsoil plough* is to break it up.

Share-plough.

The action of the plough.

Disc-plough.

Plough pans.

THE CULTIVATOR OR GRUBBER is an implement made on the type of the rake. It consists of a strong frame to which are attached many teeth, called *tines*, descending obliquely downwards and forwards. Its use is to break up the soil after it has been ploughed, so as to expose fresh surfaces for the atmospheric agencies to work on, and it also serves to draw out the weeds that have been torn up by the plough.

THE HARROW is made in various forms; and it too is simply an extension of the type of the rake. Harrows are used for turning over and breaking up clods, so that the soil may be pulverized and the particles exposed to the air and sun. Some light harrows made of chain work are used to rake the soil over seeds that have been sown, and others are

FIG. 1.—This plough was originally designed to meet the special requirements of West Indian agriculture, and it has been in use in the Islands for many years. It cuts a furrow 6 to 10 in. deep × 9 to 12 in. wide, weighs 336 lb. with 1 wheel or 376 lb. with two wheels, and requires 4 to 8 horses or oxen for draught purposes.

FIG. 2.—It can be converted (as in Fig. 2) into a double-breasted or ridging plough, or adapted to open out furrows in which to plant sugar-cane cuttings (see p. 185), rhizomes of arrowroot (see p. 437) or for moulding up sweet potatoes (see p. 451), &c., &c.

A GOOD EXAMPLE OF RIDGING: RIDGES 4 FT. APART.

A GOOD EXAMPLE OF FURROWING: FURROWS 4 FT. APART.
[*By courtesy of Messrs. Ransomes, Sims & Jefferies, Ltd.*

A disc plough ("All-Conqueror")—single-furrow, recommended for use in plantations where loose rubbish on the soil or manure requires to be effectively ploughed in. It cuts a furrow 9 to 11 in. wide × 6 to 12 in. deep, approx. weight 950 lb., requiring from 4 to 12 oxen for draught purposes, depending on the diam. of the discs, 18 in., 26 in. or 24 in. diam. and width and depth of ploughing. Two, three and four discs may be used or larger ploughs for use with tractors, and all ploughs up to four furrow can be fitted with a "Mealie" (maize) planting attachment.

NATIVES PLOUGHING WITH AN "ALL-CONQUEROR" IN KENYA COLONY.
[By courtesy of Messrs. Ransomes, Sims & Jefferies, Ltd.

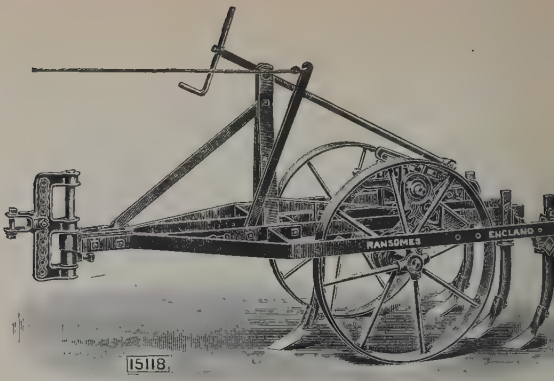


FIG. 1.—"DAUNTLESS" SELF-LIFTING CULTIVATOR WITH FIVE TINE

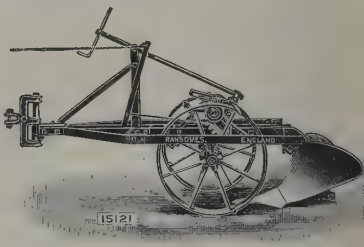


FIG. 2.—Same fitted with trenching body for making ridges or furrows such as are required for the planting of sugar-cane.

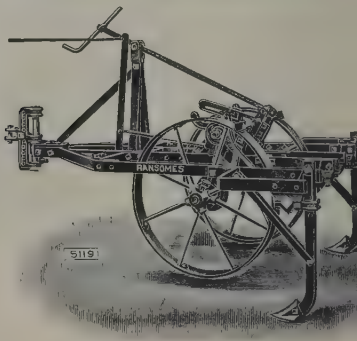
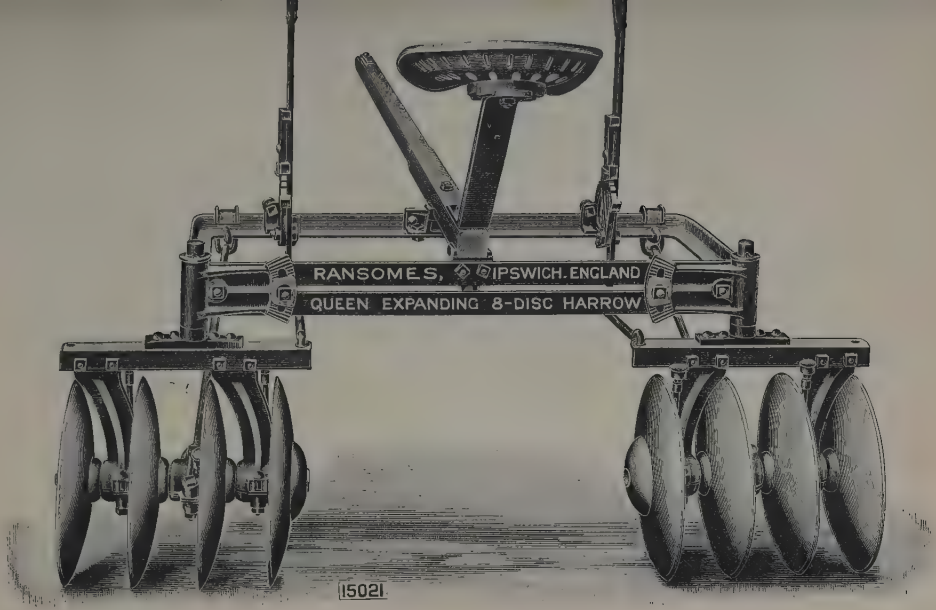


FIG. 3.—Same fitted with two subsoil tines for subsoiling between rows of plants.



Expanding "Disc Harrow" ("Queen") specially intended for cultivating the soil between rows of growing crops such as cotton, maize, sugar, &c. The disc gangs have discs 18 in. diam., each adjustable to cultivate either level or at an angle, and adapted for crops requiring the earth to be thrown either to or away from them; for maintaining surface cultivation and preventing the growth of weeds. Weight 450 lb. approx. Draught 2 horses or oxen. With a similar implement (the "Royal"), by means of extension uprights, a clearance of 3 ft. 6 in. beneath the frame can be made to admit of cultivating between the rows of taller growing crops.

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Steel harrow, teeth set zigzag at equal distances; suitable for all kinds of work; draught required varying according to size and weight, from 2 to 10 oxen. The teeth may be removed for renewal or repair.

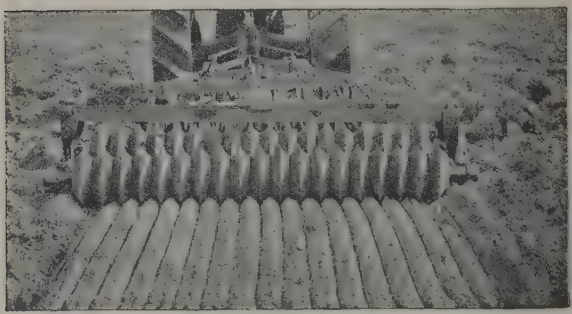
[*By courtesy of Messrs. Ransomes, Sims & Jefferies, Ltd.*

Tractor roller with Cambridge pattern rings (18 in. to 24 in. diam.), average power required for draught purposes 20 h.p. tractor. Useful for breaking down clods, after the plough or cultivator, in preparing a seed-bed, according to size of rings, soil, &c.

[*By courtesy of Messrs. Ransomes, Sims & Jefferies, Ltd.*

AN EXAMPLE OF GOOD PLOUGHING.

[*From "Farm Equipment for Mechanical Power," by F. N. G. Kranich.*



FIELD SCENE SHOWING WORK OF A RIDGED ROLLER PULVERIZER.

[*From "Farm Equipment for Mechanical Power," by F. N. G. Kranich.*

sed to drag the weeds out of the earth when they have been oosened by the ploughs and cultivators.

THE ROLLER, as its name implies, is used to smooth the arth by being rolled over it. One heavy kind, called some- mes a CLOD CRUSHER, has strong projecting teeth so that easily crushes up the clods of earth it is drawn over. The ghter kinds of rollers are used to press seeds into the earth, nd to prevent too much evaporation from the soil by making ne upper part more compact.

REFERENCE

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CHAPTER XII

PRUNING

A knowledge of pruning necessary.

It is necessary for the tropical agriculturist to have a general knowledge of the system of pruning in order that he may be able to improve his trees and to increase their fruitfulness. When a branch of a tree is cut off, much of the sap or nourishment that would have been used by it goes to the branches that remain, and more especially to those in the vicinity of the part taken away. Besides, by removing useless branches, or as it is called "thinning them out," more air and light are allowed to reach the remaining portions of the plant, and thus their assimilation of food from the atmosphere is increased. The effect of pruning does not always take place immediately, for sometimes it merely causes an increase of quantity of sap in the branches, which does not exert its influence on the fruitfulness of the plant until the next fruiting season.

Effect of pruning.

Pruning causes extra development.

But the removal of one portion of a plant, whether it be the branches, leaves, flowers, or fruit, is always followed by extra development sooner or later. If, for instance, all the first flowers of young cacao trees be taken away, as they should be, there will be increased fruitfulness at the next season. And, if all the young fruit be taken off an orange tree, flowers will break out again and the crops will be reaped at a much later time. This is very important to West Indian planters, for oranges obtain much higher prices in Europe and North America in some seasons than in

others; and, by removing the young fruit or pruning off the fruitful branches, the crop time might be altered somewhat at the will of the growers.

Observation necessary.

In pruning so as to increase fruitfulness, it is necessary to observe, first of all, on what portion of the tree or plant the fruit is borne. In some plants it is borne by the wood of the same season's growth, in others by the wood of the second season, and in others again it is borne on the wood of the stem or the mature branches. In the first instance it will be necessary to prune out branches that are backward in growth, and that have little or no fresh wood on them. In the second instance the young wood must be cut back so as to allow the strength of the plant to be put forth in pushing out flowers instead of continuing to increase the new wood. And, in the third case, the small branches and the young wood not required to increase the spread of the tree, must be taken away by the pruner. In all cases, however, *suckers* or "*robber stems*," as they are called, must be removed from trees or bushes grown for their crops, as suckers rob the plant of much of the sap or food necessary for the growth of the flowers or fruit. Pruning does not mean simply chopping at a tree with a cutlass so as to decrease its bulk, but it means an important operation, that should not be undertaken without forethought, or without some knowledge of its principles. If a branch is to be removed entirely, it must be cut off close to the stem, with a clean cut, and particular care must be taken not to injure the bark of the tree, for this bark will grow and in time heal up the wound; but, if it be torn away or jagged, a much longer time will be taken up in the process of repair of the wound, and the wood of the tree itself may become decayed and thus cause permanent injury. In order to prevent decay by the action of the air and moisture, or by insects, a good plan is to paint over the wound with tar or some such substance, if the branch pruned off be a large one. In cutting away small shoots, a sloping cut should be

What portions of the plant to prune.

Suckers to be removed at once.

Hacking trees not pruning.

Cut off branches close to the stem.

The wound to be tarred.

made coming out just in front of the bud, forming a wound at half a right angle to the branch. The reason of this is that as soon as the bud develops, as it will do shortly, the increased vigour of growth will soon heal up the wound ; but if any considerable portion of the stem be left beyond the bud, it will die and produce decay in the branch or cause the necessity of another pruning operation to remove it.

Do not prune trees when they are full of sap.

Care must be taken not to prune trees or shrubs when they are full of sap, as they will "bleed" so much as to injure the plants. The circulation of the sap is not the same in regard to time in all plants, or in the same plants growing in different places and in different climates. Observation and experiment are therefore necessary to determine the proper time for pruning, and a small cut into the stem of a plant will always show if bleeding is likely to take place.

Experiments necessary.

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CHAPTER XIII

BUDDING AND GRAFTING

In Chapter V. it has been seen that plants are sometimes propagated by bulbs—which are simply modified buds,—and by cuttings. The bulbs and the cuttings are set in the soil, and after a time they form roots and become independent plants of the same character as their parents.

Nature of budding and grafting.

Budding and *grafting* are practically the same processes as propagation by bulbs and cuttings, with the difference that the buds and grafts are made to grow on plants already rooted.

Their advantages.

The advantages of budding and grafting are, that many delicate plants, and more especially fruit trees, are rendered much hardier by their branches being made to grow on strong *stocks*—as the plants used for the reception of the buds and grafts are called. And when they become stronger they naturally give a larger return in fruit. Besides this, some plants which are very difficult to propagate by cuttings are easily multiplied by budding and grafting, and seedling fruit trees, which take a very long time to bear, can be made to fruit much earlier by these processes. In the case, too, of oranges and other fruit trees, the seeds do not always produce plants that bear fruit of the same character as that of the parent—in fact they do not "breed true." That is to say, if the seed of a very fine orange be planted the fruit obtained from the seedling, when it has grown into a tree, may after all be of a worthless character, so that after the trouble of nursing the tree from the seed,

Useful for propagating special varieties.

Seeds do not always breed true.

and after the weary waiting for years for the produce, nothing but disappointment may be the result. But by adopting the system of budding or grafting, the fruit could be reaped in a much shorter time, with the certainty that all the characteristics of the original plant would be preserved.

BUDDING.—This is simply the removal of a bud and a portion of bark from one tree, and so placing it under the bark of another tree that it will adhere and grow into a branch in the same way as it would have done on the parent stem. By this method the parent may be rapidly multiplied. The operation is performed in the following manner. The bud should be cut carefully from the branch of the parent with the base of the leaf stalk and about three quarters of an inch of the bark attached (Fig A.) ; a portion of wood will always come away with the bud if it be cut properly, and this must be gently dug out from the bark with the point of the penknife. The bud is then ready for insertion under the bark of the stock, which is done as follows :—The incisions, like the letter T with a long tail, are made beneath a growing leaf on the stock (Fig. B.). The incisions should go right through the bark, but not into the wood. The bark is to be carefully lifted up from the wood on both sides by the handle of the budding knife, and the bud is then inserted at the top and gently pushed down until it is firmly held by the flaps of the incision (Fig C.). If any of the bark of the bud remain outside, it is to be cut off so that it fits the cross cut in the stock accurately. A ligature of bast, or worsted, or narrow tape, is then to be applied so that the bud is bound down firmly but not tightly. The ligature covers up all the incision and allows the bud to expand. A leaf may now be tied over the part in order to keep off the sun and too much moisture, and the operation is complete.

How to bud.

GRAFTING, as we have seen, is analogous to propagation by cuttings. A cutting called a *scion*, is taken from the

. A.

FIG. B.

FIG. C.

FIG. D.

FIG. E.

FIG. F.

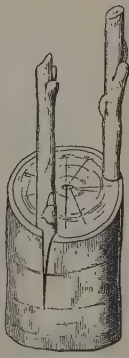


FIG. G.

METHODS OF BUDDING AND GRAFTING

The principles of grafting.

parent tree, and made to grow on the stock. There are various ways of performing the operation, all of which have different terms applied to them, but the principle involved in all is, that the whole or a portion of the bark of the scion must be in contact with that of the stock.

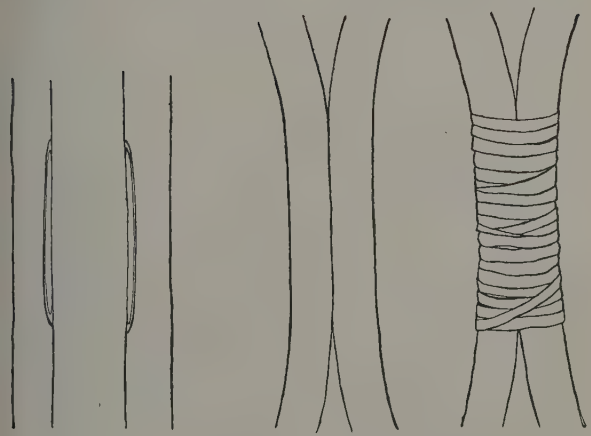
How to graft.

Whip, or *tongue grafting* is the kind most often employed, and it is performed in the following manner. The stock having been cut back, or "*headed down*," as it is termed, one side of it is pared away in a sloping direction for an inch or an inch and a half, and a wedge-shaped portion is then to be removed from the upper part. The scion is then cut so as to fit the stock in fact one is tongued into the other (Fig. D.). The scion and the stock are then bound firmly together with bast, and grafting wax (or prepared clay) is applied over all so as to keep in the moisture. The scion should have three or four buds in it, the lower one of which must be near the cut surface applied to the stock, and it is advisable also that the stock should be headed down close to a bud, as the vital processes are always more active in such situations. Care must also be taken that the bark of the stock and the scion are accurately applied to each other, but it is not necessary that both should be of the same size, although it is better for them to be so.

Other methods are *wedge grafting* (Fig. E.) and *saddle grafting* (Fig. F.). The way in which the scion and stock should be cut in these two methods is easily understood by looking at the figures. Of course the same precautions are necessary as in tongue grafting.

Grafting orange trees.

Crown grafting is very useful in orange culture, especially when it is desired to graft sweet oranges on to large and old sour orange stock. The trunk of the tree is cut right through with a saw, and then smoothed off with a knife. Two or three scions are then inserted between the bark and the wood. It will be found much easier to insert the scions if a piece of hardwood, cut the exact size and shape of their



GRAFTING BY APPROACH.

[*From "Cocoa," by C. J. Van Hall.*

MANGOSTEEN SEEDLING INARCHED ON *Garcinia tinctoria*, WITH FOLIAGE OF STOCK PLANT OPPOSITE AND BELOW THE UNION.

[*From Bull.* 202, *Bureau Pl. Ind. U.S.D. Agric.* 1911.

ends, be used to force a passage between the bark and the wood of the stock (Fig. G.)

INARCHING, or grafting by approach, as it is sometimes called, is analogous to propagation by layering. It differs from grafting in that the scion is not removed from the parent until they are both firmly adherent. It is considered to be the most certain of all kinds of grafting, and it is extensively employed for the multiplication of plants of the better kind of mangoes. The operation is performed in the following way :—A branch of the parent having been selected about the same size as the stock, the bark and a portion of the wood of each are pared away to the extent of two or three inches, and they are then bound fast together, the bark of the wounds being accurately fitted, and grafting wax applied over all. It is usual to make tongues in the stock and the scion, so that one may fit into the other, but this is not really necessary, although it helps to prevent movement —which is always fatal to union. The method is illustrated in the diagram on p. 103 and the illustration of a "mangosteen" (*Garcinia Mangostana*) on p. 104 shows the application of the principle.

Inarching mangoes and other fruits.

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PART II

AGRICULTURAL PRODUCTS

CHAPTER I

INTRODUCTION

In the first part of this book, the elementary principles of agriculture have been considered, and the student should now be well acquainted with plant life and its needs, and with the way in which Nature works to enable man to produce the fruits of the earth for his own use.

The application of the principles of agriculture to the various cultivations undertaken in tropical countries, will now be considered, and some hints on the preparation of the produce for the market will be given under each head.

Mixed cultivation.

The great fault hitherto committed by many tropical planters, has been the confining of their attention to one kind of cultivation on their land. If several different crops were taken off alternately, as in a system of rotation, or grown in different parts of the land where the soil and climate prove suitable, the planter would be in a much better position than he is now, for he would not, as it were, "have all his eggs in one basket." There is scarcely a spot on any estate, whatever the extent, in the tropical world, that is not capable of giving remunerative returns from some plant or other, and the successful planter will adapt his cultivation to his soil, and not make the futile attempt to grow crops on land and in climates quite unsuitable to them.

In all planting operations, there must be no carelessness,

Careless planting disastrous.

for a careless planter deserves to fail, and he will probably meet with disaster. For instance, if with great care and at considerable expense a large number of seedlings of cacao or coffee have been raised, and they are planted out in the fields in a careless way, they will probably die in large quantities, and the results of all the previous work and expenditure will be liable to be swept away by inattention to what, to the inexperienced, may appear to be trifling details. Writers on agricultural subjects have always urged the necessity of care and forethought in planting; and Mr. Morris,[1] the distinguished Assistant Director of the Royal Gardens at Kew,[2] whilst in charge of the Botanic Gardens of Jamaica,[3] wrote as follows :—"All the operations connected with planting are of so important a character, that too much care and attention cannot possibly be given to them. On the mode in which the plants are put in, and the plantation started, depends the whole success of the undertaking, and to realise these conditions in their fullest sense may very fitly be termed the *essential* elements in the character of a good and successful planter."

Nature to be copied.

A planter is simply one who copies nature and natural processes in order to get a large return from the soil. Nature, as we have seen, proceeds by slow and careful means, the smallest operation being done with exactly the same careful wisdom as the most gigantic one, and all things working together in obedience to natural laws, produce the wonderful world around us. A planter, who deserves the name, must humbly copy nature, not only in its indications for the treatment of plant life, but also in the careful and laborious way in which all things are done.

[1] Now Sir Daniel Morris, K.C.M.G. [2] 1892. [3] 1879.

CHAPTER II

COFFEE. *Coffea arabica. C. liberica. C. robusta. C. stenophylla.*

THE Arabian or common coffee plant came originally from the mountains of Abyssinia, and it was thence carried to Arabia and, later on, to all parts of the tropical world. Liberian coffee was discovered, fifty years ago, in the forests of the West coast of Africa, and it has been introduced into West Indies and elsewhere from the Royal Gardens at Kew. Robusta coffee is a native of the Congo, and the species *stenophylla* is the highland coffee of Sierra Leone. Although called Highland, it may thrive nearer sea-level. The berry is a small one of superior quality, said to be equal to "Mocha"—so called because it is shipped from Mocha, being grown in Yemen. "Blue Mountain coffee" (Jamaica) is another form of Arabian which takes its name from the region where grown, and in general the commercial forms are usually named according to the country of origin—"Brazil," "Costa Rica," "Kenya," "India," "Colombia," etc.

Where the coffee plant came from.

Trade names.

SOIL.—As the coffee tree has a long tap root, it will thrive only on land where the soil is deep with an open subsoil. The best soil is a well-drained loamy one, but the plant is

The plant a hardy one.

hardy and it will grow in any soil except heavy clay and sands.

CLIMATE.—The most suitable climate for coffee cultivation is that found in the mountainous regions of the tropics with a range of temperature from 55° F. to 80° F. The best

Elevation.

coffee is grown at elevations varying from 2,500 to 5,000 feet above the sea. The plant is, however, cultivated at much lower levels, and even close to the seashore. But the Ara-

Not less than 1,500 feet above the sea.

bian coffee does not do well under 1,500 feet, and it is extremely liable to blights and insect pests when grown in these low situations. As nearly all the coffee estates in Dominica were below 1,500 feet, the disastrous blight which ruined the coffee industry of that Island, was probably due in a measure, to the fact that the climate was not suitable to

Liberian coffee a low-land plant.

the cultivation. Liberian coffee, on the other hand, thrives best under 1,500 feet: it is indeed a lowland plant, and it may be grown with success in sheltered situations almost as far down as the seashore. Robusta coffee and Sierra Leone coffee also succeed best from sea-level up to 2,000 feet. An extremely wet climate is not favourable to the coffee

Exposure to be avoided.

plant, and it will not thrive in very exposed situations. But

Shelter-belts of trees.

the exposure can nearly always be modified by shelter-belts of trees; and, in those countries liable to hurricanes, they are necessary protection. They must not be allowed to grow unrestrained, however, or they will shade the coffee too much. An annual trimming with the cutlass will not only keep the shelter-belts in proper form, but the small branches and leaves cut off, if buried in the ground between the coffee plants, will rot and form a capital manure for the soil.

PROPAGATION.—Coffee plants are propagated by seed

Selection of seeds.

which should be selected from the richest and finest fruits and the seedlings may either be raised in seed beds or in bamboo pots, or other convenient receptacle, as explained under "Cocoa" (p. 147).

Numbers of plants grow up under the trees on coffee plantations, but it is safer to rely on the selected seeds.

SEED BEDS OR NURSERIES.—A sheltered piece of land in a moist situation, or within easy reach of a good supply of water, having been chosen, it should be laid out in beds for the reception of the seed. If possible, the nurseries should

Nurseries to be in sheltered situations.

1 2

COFFEE (*Coffea arabica*).

1. Flower. 2. Fruit.

be made near the planter's house so as to be frequently overlooked, for they require constant attention, and it may be necessary to visit them at nights, to kill any nocturnal insects that are fond of cutting the stems of the seedlings. When it is not intended to plant the coffee on a very large scale, the seeds may be grown in boxes or pots nearly filled with

They require constant attention.

Plants raised in boxes

loose earth and raised some distance above the ground, for in this way the young plants can be better attended to, and there is not so much danger of the ravages of caterpillars and other voracious insects that sometimes destroy the leaves and young plants.

Seed beds to be manured.

The seed beds must not be too wide, they ought to be well manured if the soil be poor, and the earth should be dug up and pulverised—every root and stone being carefully removed. If the land be stiff clay, some sand or charcoal dust should be mixed with it, as the delicate rootlets of the young plants require a loose soil for them to penetrate easily.

Loose soil necessary.

Fresh seeds to be sown.

The seeds fresh from the pulp are to be placed in the ground with their flat side downwards, at a depth of about an inch and a half below the surface, and three inches from each other. A thin layer of finely broken charcoal may, with advantage, be placed over the seed beds, for it keeps down weeds and helps to retain moisture. In favourable weather the seeds will germinate in about six weeks, and the seedlings will be ready to transplant in from eight to ten months. Should dry weather come on after the seeds are planted, the nurseries ought to be well and frequently watered. The beds must be constantly weeded, and the weeds be pulled up before they grow to a large size, otherwise there will be the danger of pulling up the coffee plants with them. A reserve of plants should be kept to supply vacancies occurring in the plantation by reason of some of the plants dying after they are put out in the fields. Other beds are to be made, the soil being prepared in the same manner as for the nurseries, and the seedlings are then planted in them about 8 or 12 inches from each other. In this way, they will grow and keep pace with the plants in the field ; and, when vacancies occur, they can be supplied with well-grown plants. An excellent way, when planting on a small scale, is to transfer the seedlings into bamboo pots, and to keep them at first in a shady and moist place, and

Seeds germinate in six weeks.

Constant weeding.

Reserve plants.

TREE OF ARABIAN COFFEE (*Coffea arabica*) IN FULL BLOOM.
[*From "The Cultivation and Preparation of Coffee," by J. P. Ugarte.*

BLUE MOUNTAIN COFFEE (*Coffea arabica*).
Growing at Kabete, Kenya Colony.
[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

afterwards to harden off the plants by placing the pots in more exposed situations. Hardening off the plants.

BAMBOO POTS.—As a good many plants cultivated by the tropical agriculturist are raised to great advantage in bamboo pots, it is as well for particulars to be given of the way of planting seeds and seedlings in these useful receptacles. A bamboo stem is a hollow cylinder divided into many compartments by cross partitions of thin, hard, woody tissue. At each joint, or node, or knot, where the stem is swollen, there is one of these partitions, and thus a bamboo stem has as many compartments as it has nodes. If the stem be sawn through, an inch or so below each node, there will be made a number of hollow cylinders from 10 to 14 inches long, and from 3 to 4 inches in diameter, open at one end and closed at the other. These are the bamboo pots, and there is nothing else so admirably adapted for raising plants, and so cheap and plentiful in most tropical countries. The pots being deep, accommodate the tap roots better than the ordinary flower pots. Their sides are glazed with a hard siliceous material which does not allow evaporation, and thus prevents the roots from being chilled and the soil from drying up, as is the case in porous earthenware pots. The bamboos, too, are strong and hard, and not broken by falls or knocks, and they are so inexpensive as to allow a pot to be destroyed for each plant. On estates where there are no bamboos, or where none can be easily got, the planter should grow several clumps, if only for the sake of making the stems into pots.

How bamboo pots are made.

Utility of the pots.

A plant is set in a bamboo pot in the following way :— The pot having been pierced below with a large hole for the purpose of allowing exit to the water, some small stones should be put in so as to prevent the earth from choking the hole, and so as to favour drainage. On the stones some moss or rotten leaves should be put in order to keep the earth from getting in amongst the stones, and thus choking the channels for the passage of the surplus water. The earth must now be filled in to within an inch of the top, and the pot knocked several times to settle the soil. When the pot

How to place the plant in the pots.

is used for raising a seedling, the seed may now be sow
but if plants from the nurseries are to be potted off, t
earth must be filled in only to the level of where the end
the longest root will touch, and then the plant is put in
being held in the centre of the pot—and the soil is packe
round the roots ; a few sharp taps on the bottom or at th
sides of the bamboo will cause the earth to settle nice
amongst the roots and prevent any of them from being turne
up or doubled on themselves. The seedling being no
planted in the pot, the earth should be pressed down rathe
tightly about the stem, so as to prevent too much evaporatio
from the surface, and the operation is complete. The reaso
Watering the plants. that a space of an inch is to be left between the surface o
the earth and the top of the pot is because, in watering th
plant, there is a better chance for it to get a sufficien
quantity of moisture. The best way in watering, is to use
can with a spout, and gently to pour in the water until it run
over the sides of the bamboo. For all practical purposes
the above notes may be applied to the use of baskets
referred to on p. 147 under "Cocoa."

PREPARATION OF THE LAND.—Having finished the nur-
series, the attention of the planter must now be directed to
Forest land best for coffee cultivation. the preparation of the land. Forest land rich in humus is,
of course, best suited for a new plantation, inasmuch as the
plants will grow better in virgin soil, and the land will not
Cutting down the forest. require any manure for a long time. The forest having been
cut down, the branches must be lopped and strewn evenly
over the ground before the fire is set. Of course the felled
forest trees must be allowed to remain for a time exposed
to the sun, otherwise the smaller branches will not catch fire
properly. Where possible, the more succulent and herba-
ceous matter might be packed in lines between the young
coffee trees, in order that, by its rotting, it may add to the
richness of the soil. It is also advisable to uproot all the
stumps of trees that have been cut down and to remove these
from the plantation area as a safeguard against disease.

LINING.—The land having been cleared, the next thing is to line it out, pickets or stakes being placed at each spot that is to be occupied by a coffee tree. Care should be taken to get the lines symmetrical, for a badly lined estate is an offence to the eye, and it causes much trouble in giving tasks and in picking the crops. On the small properties of peasant proprietors where coffee is cultivated, the trees are sometimes so overcrowded as to injure each other and to diminish the crops. It is a mistake to imagine that the greater the number of trees on a given piece of land, the greater will be the return in crops. As we have seen in the first part of this book, the atmosphere and sun and rain have a great deal to do with plant growth : and, in order for these important agencies to work properly, there must be sufficient space around a tree for the air to circulate freely and for the sunlight to enter. Crowding of plants prevents this and does much harm in other ways. The roots intertwine and rob one another of the available plant food, which as we know now exists in the soil in a soluble condition. In spacing out the lines the triangular system of planting, in preference to the square or rectangular system, is suggested as the best. The head of the coffee tree requires the greater space for full development which the first mentioned is calculated to give it, and the system has also the advantages of giving a few more trees to the acre and in counteracting to some extent the soil-wash on sloping ground. The lines may be kept straight with the aid of a lining out or prismatic compass.

Straight lines advisable.

Overcrowding of the trees to be avoided.

A good way to line out the land is to get a number of long stout cords, and to stretch them over the field at regular distances. A similar cord held by a person at each end is then stretched across all the other cords ; and, where the single cord touches all the others, pickets are put in. In this way the lines will be perfectly straight, and the distance of the pickets from each other can be made to suit the desire of the planter.

How to line.

The distances at which coffee trees should be planted will

Distances.

vary according to the soil and to the lay of the land. On rich land the plants may be put in at the maximum distances allowed, from ten to twelve feet, catch-crops or green manure plants being grown until the trees mature. On poor soil and also on steep hillsides, shorter distances may be adopted, but the trees should never be closer than five feet by five feet, which would give 1,740 trees to the acre. Liberian coffee being larger and more vigorous than Arabian coffee, the distances of planting may be wider, and in this case the trees are usually planted at ten feet by ten feet, which gives 435 trees to the acre, or in general, eight feet by eight feet (680 trees to the acre), ten feet by ten feet (435 per acre), or twelve feet by twelve feet (302 per acre) for all the species.

Not closer than five feet.

HOLING.—Where the virgin soil is rich and friable, it is necessary to hole the land. That is to say, holes must be dug where every picket stands, and these holes should be from one foot to two feet square and from a foot and a half to two feet deep. In clays and poor soils the larger size is preferable, and on a good, rich, loamy soil the smaller size will be sufficient. The holes must be left open for a few weeks so as to allow the air to get into the sub-soil and to act on the dormant constituents, and the earth dug out should be placed below the hole if the land be hilly and anywhere on one side if it be level. In filling the holes, none of the earth taken out must be put back, but surface soil from the vicinity and weeds must be put in, care being taken to keep out stones and large roots. The more weeds buried the better, as they answer the purpose of a green crop manure. After a week or two, the weeds will rot and add richness to the soil, which will sink down and leave a shallow hole that must be again filled up with surface earth; and, if the land be poor, some farm yard manure or compost may with advantage be added. It is advisable to raise the earth somewhat, leaving a small mound where the hole was, and in the top of the mound the young tree is to be planted.

Size of holes.

Holes left open for a few weeks.

Filling the holes.

The earth to be raised in a mound.

The object of the system is to allow for the subsidence of the earth, as it is found, no matter how well the holes are filled, that sinking always occurs; and thus, after a time, the young plants will be left in a depression unless the soil be heaped up as described.

PLANTING OUT.—The trees should be planted out, if possible, at the commencement of the rainy season, and on no account should the seedlings be put in the fields during dry weather; for, until the plants are firmly rooted in their new situations, a few days' sun and dry weather will be almost certain to kill them. Temporary shade may, however, be afforded by fixing small branches of trees in the ground around the plants, or a few sticks, pushed into the earth, may be made to support plantain or fern leaves in such a way as to give light shade to the young coffee trees. In removing the plants from the nurseries, care must be taken not to injure the roots; and, where it can be done, a ball of earth should be removed with the plants. If the roots be much injured, it is as well to take off a few of the lower leaves so as to restore the balance between those parts above and those below the ground. When plants are raised in bamboos, on no account should the pot be split and then put in the ground with the plant inside it, for the rotting wood, remaining at the root of the young tree, will be liable to injure it. The proper way is to have the soil in the pot well wetted before taking them into the fields; and when the hole is ready for planting, each pot is to be split by a sharp blow of the cutlass on either side, and then by using a little force the sides will separate, and the plant with its roots undisturbed and covered with soil, can be at once set in the ground, and failure will be scarcely possible. Of course when stones have been put in the pot for the purpose of drainage, they must be gently turned out of the soil with the fingers before the plant is set in the earth. After the young tree is planted, the soil should be pressed down firmly

Seedlings to be planted in wet weather.

Temporary shade.

The roots not to be injured.

How to remove the plants from the bamboo pots.

round the stem to prevent too much evaporation from the roots, and in very windy places it will be as well to put in a short stake close to the tree, and to tie the plant when large enough to it so as to prevent too much shaking. In all planting operations extreme care must be taken to prevent the sun from burning the roots, and whilst the plants from the nurseries are being removed to the fields they should be well covered up with plantain or other leaves.

Staking the plants.

Watering the plants.

If dry weather come on suddenly after planting, the seedlings ought to be watered at least once a day until they become well rooted, for unless this be done a large proportion will die. When the young plants are rooted they require careful nursing until they throw out several pairs of branches.

Planting at stake.

Another way of planting is to dispense with the nurseries and to sow the seeds in the open field in the place where the coffee tree is to be grown. Holing the land must, however, be adopted except in rich, friable, virgin soil. Three seeds are sown in each hole at a distance of six inches from each other, and should all the seeds grow up well, the largest and strongest and best formed tree is allowed to remain, the others being taken up to be used when necessary for supplies or for planting fresh land. This system is called *planting at stake* and each hole requires much careful attention,—it must, indeed, be regarded as a miniature nursery.

Shade necessary in the lowlands.

SHADE.—Much shade is not required by full-grown coffee trees, except when the Arabian species is planted in the lowlands, and then shade becomes necessary. The shelter belts may be allowed to grow up in this case, until the high branches of the trees overshadow the cultivation, for a portion of the day. Pois doux (*Inga laurina*), the rose-apple (*Eugenia Jambos*), mango (*Mangifera indica*) and annatto (*Bixa Orellana*—see p. 373) may be used for these belts. Liberian coffee growing in the lowlands, and the Arabian coffee growing in the mountains over 2,000 feet elevation, do not need shade, and the belts of trees will be

Shelter belts of trees.

Protection from winds.

equired only for protection from high winds. But when the offee trees are young some shade is almost a necessity, except in very sheltered and damp places. Plantains and ananas may be used for this purpose, but they must not be lanted too close to the coffee. The pigeon, or Congo pea (*Cajanus indicus*) makes an excellent shade plant for the oung trees and is also a good green manure. Robusta offee is grown under shade in Java; Arabian coffee is rown without shade in Brazil, Jamaica (Blue Mountain) nd Alta Vera Paz (Guatemala), whilst in S. India and the ast it is grown mostly under the shade of "silky oak" (*Grevillea robusta*). Some diversity of opinion exists as to hade requirements in various parts of the coffee world; but n general, when the trees commence to bear the shade lants growing amongst them had better be taken away ltogether, for otherwise the coffee will become "leggy," that s to say, their stems will run up quickly with long intervals etween the branches, the leaves will be larger and few in umber, the stem will be weak, and the crops will be small. A fully grown coffee tree, in a good situation as regards soil nd climate, delights in the sun, and it is only in the case of he young and delicate plants that such shade is useful.

Pigeon peas enrich the soil.

Leggy trees.

Sun beneficial to mature trees.

WEEDING.—After the young plants are established in the elds, they will require constant weeding and this necessity n the cultivation of coffee was recognized by the early lanters in the West Indies. Laborie, who wrote in 1797, first book on coffee cultivation, entitled *The Coffee Planter of San Domingo*, says,—"There is not perhaps ny plant which requires more purity of soil than the coffee ree. Weeds keep it back, cause it to grow yellow, fade, vither, and even perish." The weeds may be put in heaps o rot, and then they can be used to cover the roots of the offee trees, but they must be rotted before this is done, and nless the earth be shaken out of the roots, and the heaps urned once or twice, many of the weeds will live and grow

Constant weeding necessary.

Laborie.

The weeds to be buried.

vigorously notwithstanding that they have been dug up. A better way is to bury the weeds, and thus turn them into a green crop manure. The holes should not be dug too near the coffee trees, and the weeds must be buried in a different hole at each weeding. Where clean weeding is practised it then becomes advisable to plant green manure crops (see p. 60) or suitable cover crop, to prevent soil erosion.

Advantages of topping the trees.

TOPPING.—If the coffee trees be allowed to grow unrestrained they will become very tall; indeed, the Liberian species has been known to grow forty feet high. In these cases it is very difficult to pick the berries, for the trees, as a rule, bear mostly at the top, as, frequently, many of the lower branches die out as the trees increase in height. The system of topping therefore is advised, and it consists of cutting or "nipping" off the top of the tree after it has attained such a height as will allow all the berries to be picked without difficulty. Besides this advantage, the topping increases the spread and the fruitfulness of the lower branches, and prevents strong winds from having as much effect on the plantation as they would if the trees were higher. In exposed situations in the mountains, the trees may be topped at three feet, and in shady places where the soil is good, they should never be allowed to grow higher than five feet. A good practical range is from four and a half feet to eight feet or in reasonable proportion to the distance apart and the situation in which the trees have been planted. It has been recommended, in the case of coffee planted on lowlands that the trees should be allowed to grow up unrestrained, as they are then more fruitful, but in this case the berries will have to be picked with the aid of step-ladders; for if the branches be pulled down, the stems are liable to break or split.

Trees in the lowlands not to be topped.

The importance of pruning.

PRUNING.—Proper pruning of coffee trees is very important, for if they are allowed to grow unchecked they will become a tangled mass of stems, branches and leaves, and

ney will bear very small crops. The tree having been top-ed, a rod the proper length being used as a guide, all uckers must be removed. These are vigorous erect shoots nat spring out along the stems, and sometimes on the ranches, and they will grow so vigorously if left alone as to ob the tree of the sap destined to form fruit, hence they are alled "robber" or "gormandising" stems or branches. It s best to remove them whilst they are young and then they an be rubbed off with the finger and thumb by a process alled "handling." A well-formed coffee tree has a straight entral stem from which side branches called *primaries* are iven off, and these primaries give off other side branches alled *secondaries*, which sometimes branch again. Now, in proper system of pruning, none of the secondary branches lose to the main stem must be allowed to remain, for they ught to be pruned off so as to allow a clear space round the tem for the free circulation of the air and for the entry of ght. The systems of pruning may vary in different countries. n Central America the method is based on cutting secondary nd lateral branches, thus encouraging new growth on the rimaries, but in general the principles are that the ripened ood of the previous season's growth bears the main crop nd that the admission of light and air are necessary. On the rimary or principal lateral branches, at each node or knot, ne secondary branches are usually given off in pairs—one n each side of the branch, but sometimes instead of a pair, whole bunch of branches growing in different directions nay be met with. Pruning is required in such a case, for is well to remove all but the two best branches with a narp clean cut, as was explained in the chapter on pruning.

How to prune the trees.

Epiphytes to be taken away.

MANURING.—If forest land be cleared for the plantation, o manure will be necessary for several years, but the case different if the land is already under cultivation. Then nanure is indispensable, and, of course, farm-yard manure r compost is the best. It is well, therefore, for the coffee

Farm-yard manure the best.

planter, or indeed any other planter, to keep animals i order to be able to obtain valuable manure for his trees. A first the manure may be simply laid round the roots of th trees, and then covered over with surface earth, or it ma be carefully forked into the soil around the roots; but, lat on, it will be necessary to bury the manure in holes near th

The holes for manure.

trees. The holes should be about two feet long, a fo deep, and a foot wide, and at a distance of not less than tw feet from the stem. In digging, all the large roots of th coffee trees that are unearthed should be left, but the small ones may be cut with advantage. The manure should the be spread at the bottom of the hole and covered with weed and surface earth, which ought to be well rammed down s

The position of the holes.

as to prevent washing during heavy rains. If the coffee h planted on hill sides, the holes ought to be dug above th trees, so that the soluble portions of the manure may b washed down to the roots; but, on level land, the position the holes is of no importance, only they must not be dug the same spot at each manuring.

Catch Crop.—Whilst the young coffee trees are growin the vacant ground may be planted in maize, plantain tanias, sweet potatoes and other such food products, accor ing to the desire of the planter or the requirements of th local markets. This system, which is called catch croppin

Catch crops recommended.

is really a very good one, although some planters disappro of it. The unoccupied part of the land will be giving son return, and the tillage of the soil necessitated by the cultiv tion will do good to the young coffee plants. Besides, th shade produced by the plants grown for the catch crops w prove beneficial to the coffee, and the weary waiting f returns from the cultivation will be broken by the sale of th

Catch crops to cease at the second year.

produce. Of course, care must be taken not to allow th "catch crops" to encroach too much on the coffee, and aft the second year they should be discontinued.

Enemies to the Coffee Trees.—There is, perhaps, n

cultivated plant that has so many enemies, both animal and vegetable, as the coffee tree. In Ceylon, the cultivation of coffee was practically ruined some years ago by a fungoid, or vegetable blight which attacked the leaves, and which was found to be incurable. In Dominica, an insect blight called the "white fly" killed out nearly all the trees at the early part of the nineteenth century; the same blight is now in Brazil, and it is doing harm to the coffee cultivation there; it may be said to exist also in Jamaica and other of the West Indian Islands, but it does not commit there the depredations it did in Dominica. The mealy bug, a curious insect like a flake of snow, does much harm in some places, but it can be got rid of by planting pine apples between the coffee, as the bug is very fond of the plant and will quit the coffee trees for them. In some countries much damage is done to the trees by a beetle called "the borer," because it bores holes in the stem or root of the tree and thus often causes its death, but these insects can be searched for and killed. Scale and shell insects sometimes appear on the trees; they are little white or brown scales applied to the bark of the tree or the epidermis of the leaf; their excrement is often in the form of honey-dew, which is afterwards attacked by a black fungus, like soot. This is often found covering the leaves, and usually associated with ants. The scale blight can easily be got rid of by washing the plant with soap and water, and most other insect blights can be killed by syringing, or watering the trees with soap-water, to which a very small quantity of kerosene oil has been added, the whole being thoroughly stirred up. Care must be taken not to put in too much of the kerosene oil, or it will kill the trees. In the case of all blights, it will probably be found that the trees are weakly on account of bad cultivation, an exhausted soil, or perhaps unsuitability of climate. Now the first thing to be done is to endeavour to restore the vigour of the trees by proper tillage, careful weeding, and judicious manuring, and very frequently these are the only

The Ceylon blight.

The "white fly."

The mealy bug.

The borer.

Scale blight.

Associated with ants.

Insecticides.

Weakly trees.

A COFFEE TREE (*Coffea arabica*) WELL LADEN WITH BERRIES.
[*From "The Cultivation and Preparation of Coffee," by J. P. Ugarte.*

HARVESTING COFFEE IN COLOMBIA.

[*By courtesy of Mr. J. P. Ugarte (Messrs. E. H. Bentall & Co., Ltd.)*

resources of the planter. But, then, fortunately they are powerful agents in the prevention and cure of blights, for a vigorous tree may throw off a blight under which a weakly one would wither and die.

Vermin.

Rats and mice when plentiful are very injurious to the crops. The fruit of the coffee consists of two seeds enveloped in a sweetish pulp of which these destructive animals are immoderately fond. In crop time one will often see parchment coffee on the ground under the trees, and this is usually called "rat coffee," for the rats have eaten the pulp and dropped the beans enveloped in their parchment. The rats and mice may be caught in traps or poisoned, but perhaps the best way is to keep a good dog that has been taught to catch such vermin.

Rat coffee.

Gathering the crops.

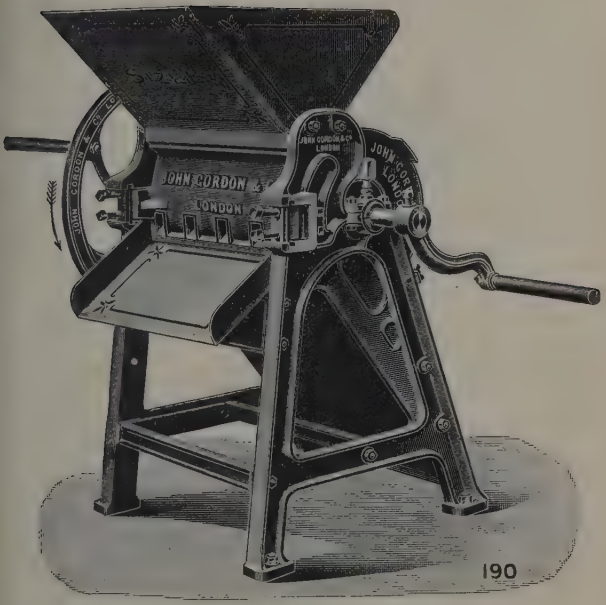
CROPS.—In the case of Arabian coffee, as soon as the berries become red they must be gathered, for otherwise there will be a great loss to the crops, as the fruit does not remain on the trees for any length of time, but falls to the ground. The reverse is the case, however, in regard to Liberian Coffee, for in this species the ripe berries remain on the trees and they can be gathered at the planter's leisure. This is an immense advantage in places where sufficient labour cannot be obtained to gather in the crops in a short time. The berries are usually picked from the trees; but, in Arabia, cloths are spread beneath the trees and the berries are shaken into them. This is a preferable way to gather the crops when it can be employed, for by it none but ripe berries are obtained, and unripe fruit will deteriorate the quality of the coffee. The crop time varies in different countries, but coffee is ripe at some period in the second half of the year, August, September and October being the most frequent months. Liberian coffee, however, is much later as the full crop does not often come in until December and then goes on to January and February in the next year. But this species is very prolific, and it bears a few berries

Advantages of Liberian coffee.

Ripe berries only to be gathered.

The crop season.

Characteristics of Liberian coffee.



COFFEE PULPING MACHINE—CYLINDER TYPE.

The ripe cherry coffee passes with a stream of water from the hopper, between a rotating drum covered with a punched copper sheet and a "breast" which is adjusted close up to the drum. This breast has channels down which the coffee cherries are dragged, the outer pulp or skin being removed during the passage. The pulped coffee is delivered through the holes in the breast and passed to the fermenting tanks, while the skins are delivered by a shoot towards the back of the machine. This machine will pulp 4,800 lbs. of ripe cherry coffee in an hour when worked by power.

BENTALL'S "BABY" COFFEE PULPERS.

For use on small plantations, or for obtaining samples on large estates.

Approximate capacity: Size No. ½, 1 cwt.; Size No. 2, 2½ cwts.; Size No. 2½, 5 cwts. of ripe berries per hour.

all the year round, thus buds, flowers, ripe and unripe berries are often seen on the trees at the same time; and, as the flowering frequently comes on before the crop is gathered, the planter is often bothered a great deal, for, as a rule, the trees must not be interfered with at all whilst they are flowering.

Returns.

The yield of coffee varies, of course, according to soil, climate, and cultivation, but it may be said to be from four to twelve hundred-weights to the acre. A pound per tree, on an average, would be a very good return, but in favourable situations and under proper cultivation some trees will yield much more. The Liberian coffee trees are much more prolific than the Arabian kind, and each tree yields from one to eight pounds of clean coffee. About three bushels of berries may be picked by a good worker in a day, and this will yield about thirty pounds of dry coffee or about ten pounds to the bushel in the case of the Arabian coffee, but the pulp of Liberian coffee is much thicker, and the berries of this kind will not give so much clean coffee to the bushel; but the trees, by bearing larger crops, compensate for the greater loss in pulp. Robusta coffee may yield 17 cwts. per acre.

A pound per tree.

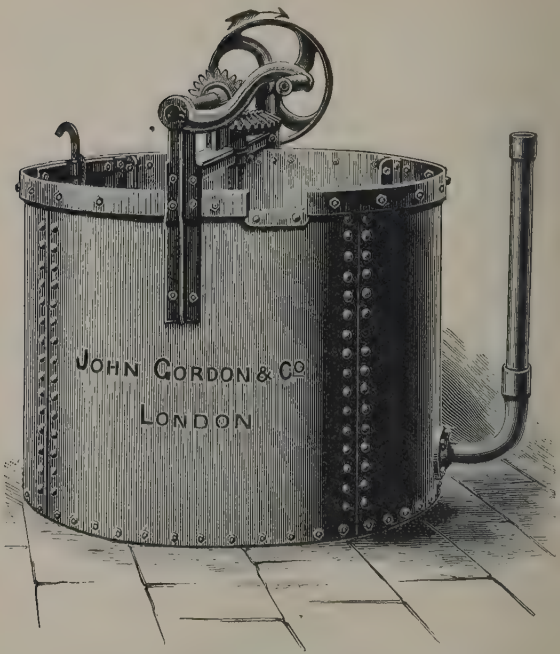
Ten pounds of clean coffee to the bushel of berries.

PULPING.—The operation of removing the pulp from the berries—sometimes wrongly called "cherries"—is termed pulping, and it may be done by the hand, by pounding the fruit in a mortar, or by pressing the berries with a rolling motion between two flat boards. These methods, however, will only answer when a small quantity of coffee has to be treated, and, on a large scale, a machine called a *pulper* must be used. The principle on which pulpers are made is that of a roller covered with a copper *grater*, made to revolve against a smooth surface, the *breast*. The grater is approached so closely to this that the berries will be crushed without the coffee bean and its parchment covering being injured; and, as the breast is movable, it can be set to the different sizes of the beans. Thus in pulping Mocha

Berries not "cherries."

Machinery.

Mocha coffee.



VERTICAL TYPE OF COFFEE WASHER.

The pulped coffee is delivered into the tub in charges, a supply of clean water is admitted, and the whole is kept in agitation by revolving stirrers fixed on the central spindle of the machine. The skins and light coffee rise to the surface of the water and float away by the overflow. The washing is continued until the water is clear, and then a door at the bottom is opened, and the washed coffee is discharged for draining and drying. It is possible to wash, with this machine, 6,000 lbs. in an hour.

coffee, which is a variety of the Arabian species with very small beans, the breast should be fitted very close to the grater, and, in the case of the large berries of the Liberian coffee, it must be set much further away. There is a *hopper* at the top to receive the berries and to conduct them to the grater, and below, a *sieve* is so arranged, on an inclined plane, that the crushed berries falling on to it are set in motion, the beans passing through the sieve and the pulp or *tails* rolling away (see p. 131).

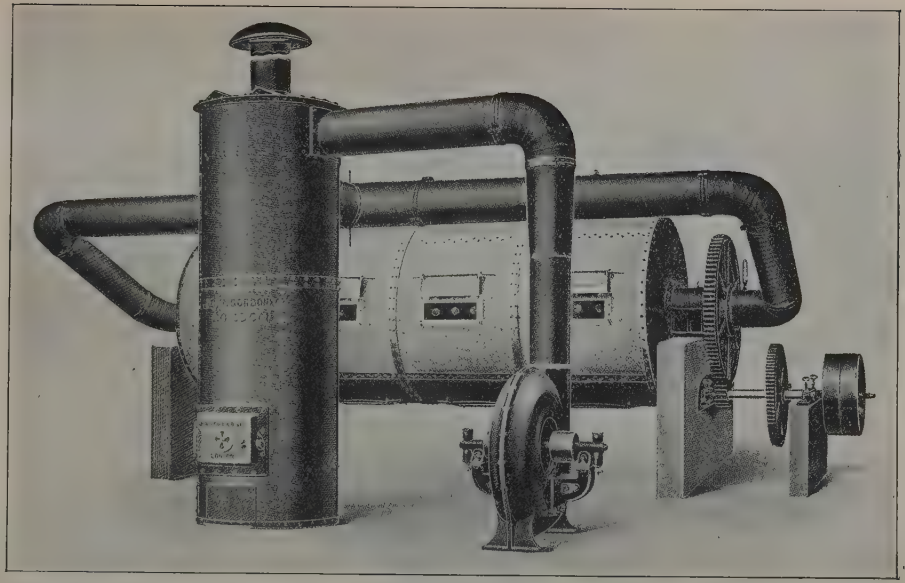
Fermentation and Washing.—As the beans come from the pulper, they are covered with a sticky mucilaginous material, which is removed by fermentation or by soaking in tubs or cisterns of water. When they are to be fermented, they are put in barrels or tubs and allowed to remain for twenty-four hours, or until the mucilage is easily separated; and then they are washed in water, and put out to dry in the sun in trays or on platforms. The coffee is then in the form of "parchment." The processes involved may also be effected by means of the machines illustrated on pages 134 and 136.

Cisterns or coffee washers and dryers.

Hulling or Peeling.—This consists in the removal of parchment and the thin under-coat called the silver-skin, which is done by various machines called *hullers*, or by pounding the parchment coffee in large wooden mortars. When the hulling has to be done on a very large scale a circular trough, in which a large and heavy wooden or stone wheel is made to revolve, is employed. The parchment coffee is put in the trough and the wheel is made to pass over it. The parchment is crushed and broken into small pieces, but the coffee itself, if properly dried beforehand, is uninjured. In all cases the parchment coffee must be well warmed in the sun before it is peeled, and on no account should the peeling operation be performed on a wet or damp day. A bushel of parchment coffee will usually give half the quantity of clean beans, but the proportions vary very

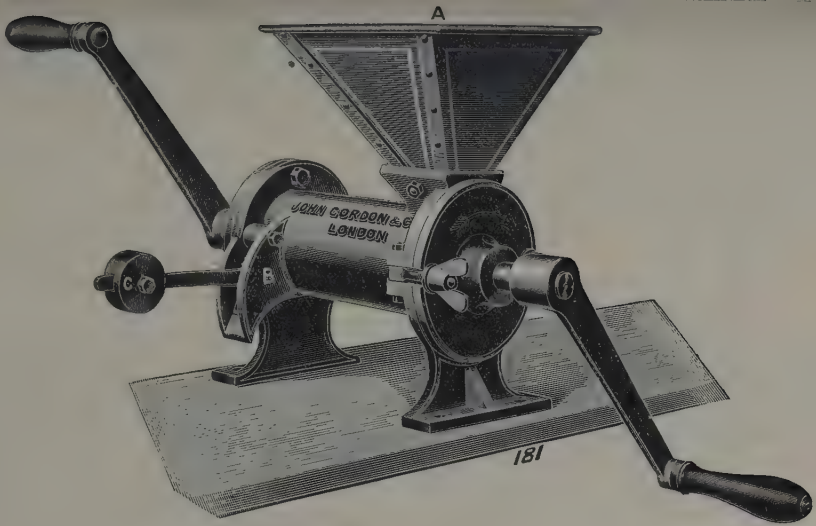
Hulling machinery (see p. 137).

Hulling not to be done in wet weather.



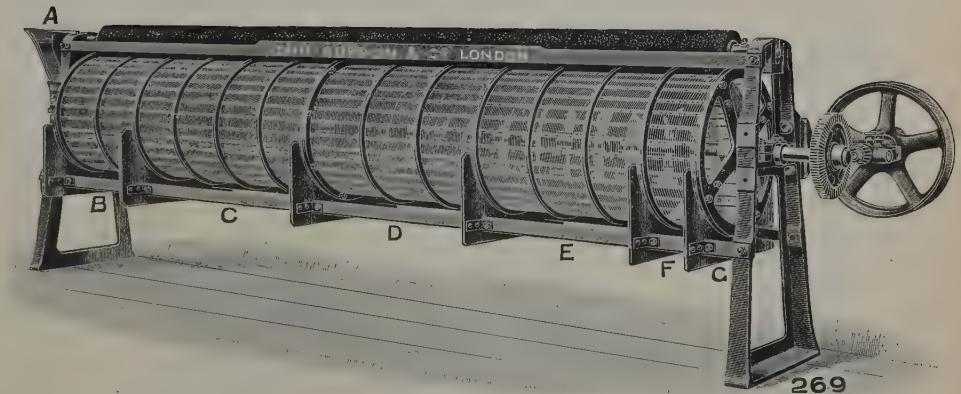
COFFEE DRYER.

The mechanical drying of coffee is carried out in rotating drums, heated by hot air, this air being forced through the drying drum by a powerful fan. This illustration shows a typical outfit consisting of a fire heater, fan and drying cylinder. Where steam is available this is often used for heating the air. The drying takes 24 hours and the



COFFEE HULLER.

After drying, the parchment shell has to be removed from the beans. This is usually effected by passing the coffee through a machine fitted with a rotating screw working within a fluted casing. This illustration shows a small machine of this type that can be worked by hand power. The larger machines have combined with them a fan which removes the husk and dust after shelling, and so deliver the beans quite clean. With the smaller machines the shelled coffee is passed through a separate winnower. This machine will hull 300 lbs. of parchment coffee per day, but larger sizes are made, capable of dealing with upward of 20 tons a day.



COFFEE GRADER.

The shelled and cleaned coffee is now ready for grading. This is a most important process. This illustration shows a simple machine with a single cylinder having various sections wound by wire, which divides the coffee into its different classes—flat beans, "peaberry," "elephant" and "triage" (or broken). The cylinder is kept clean by a rotating brush which is fitted on the top. These graders are made in various sizes, grading from 2½ tons to 10 tons per day.

much according to the kind of coffee and the condition of the cultivation. The shelled and cleaned beans are then graded. Grader (see p. 138).

WINNOWING.—In order to remove the broken parchment and silver skin from the beans after the hulling process is effected, the whole is passed through a winnowing mill—which consists of a fan made of four plates turned rapidly by a handle, whereby the wind is made to pass through the coffee and the chaff, which fall gradually through a slit in the hopper. The coffee, being heavy, falls into a receptacle at the bottom, and the chaff is carried away by the wind. The winnowing mill.

DRY BERRY.—Sometimes the coffee berries, instead of being pulped, are dried whole by being spread out on platforms exposed to the full rays of the sun. The drying of the berries in this way takes three or four times as long as the drying of parchment coffee. When perfectly dry, the berries are hulled and winnowed in the manner first described, but the process is more troublesome and difficult than when the pulp has been removed. It is said, though, that coffee prepared in this way is heavier and of a finer quality, and some planters recommend that the method should be generally adopted, though drying and shipping in the berry is not profitable. There is a firm in London that receives the coffee in *parchment* and prepares it for the market at a moderate cost per hundredweight. Drying the berries produces better coffee.

There are hulling machines capable of dealing efficiently with dry-berry and parchment coffee, but others are constructed to hull or peel parchment coffee only. Large machines are usually fitted with a fan to remove the husk and dust after shelling, as described on page 137, and they may also be adjusted to remove the *silver-skin* and give a final polish to the bean. Machines for hulling dry-berry.

Of the world's immense trade in coffee it is probable that Trade.

one half or more of the supply is produced in the State of São Paulo, Brazil, where the industry is regulated by an Institute established under the Federal Government. An export tax of 5*s.* per bag (approx. 132 lbs.) produced in or transported by rail or road through the State is imposed, the volume of trade involving a circulation of several million bags in the course of a season. Recent prices on the London market for Santos coffee were approximately 95*s.* to 100*s.* per cwt., with "Mocha" (Arabia) quoted at 125*s.*, "Kenya" 135*s.* to 140*s.*, Costa Rica 160*s.* to 165*s.* and Jamaica (Blue Mountain) 200*s.* to 210*s.* per cwt. The total imports into the United Kingdom amount to about sixty-five million pounds a year, East Africa—including Kenya, Tanganyika and Uganda—being the principal Empire source, with Costa Rica the most important source in foreign countries. For comparison it may be interesting to note that the coffee imports into the United States exceed one thousand million pounds per annum.

Market prices.

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CHAPTER III

CACAO, *Theobroma Cacao*

Habitat of the tree.

THE cacao tree is a native of the forests of Central America, and species of it are said to have been found wild in Jamaica, Martinique and South America. Nearly the whole of the cacao produced in the world comes from Central and South America, the West Indies, Ceylon, West Africa, and other parts of the tropics of the old world. The

Description of the tree.

tree, growing in a good soil, when left to itself will reach a height of 20 or 30 feet, and spread out to an extent of 10 feet or more on each side. At the height of a few feet from the ground it sends out from three to six lateral branches, without any sign of a leading stem, and it is only when the branches are matured that a leader springs out from the side and not from the centre of these branches. The flowers are small, and they come off in a bunch from the stem or the larger branches, at the place where a leaf formerly existed. It is very rare that more than one of the flowers develop into fruit, and thus many more flowers are borne on the trees than fruit pods.

VARIETIES.—There are many varieties of cacao, as is usually the case when fruit trees are cultivated ; and in all cacao countries there are doubtless to be found distinct races produced by differences of soil, climate, and other influences. Some years ago, Mr. J. H. Hart, when Super-

intendent of the Trinidad Botanic Gardens, sent the author no less than eighteen distinct varieties of cacao growing in that island, twelve of which were described as first class kinds. It is unnecessary, however, to enumerate the names here, for if any one learns the distinctive characters of a good

Trinidad Cacao.

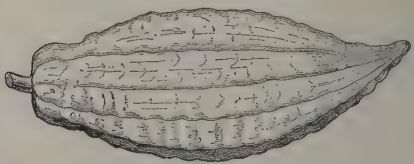
CACAO (*Theobroma Cacao*).

1. Flower. 2. Fruit cut open showing seeds. 3. Seed.

ariety, he can always select the best seed himself. A draw- Description of a pod of the best variety of cacao.
ng of a pod of one of the finest kinds of cacao is seen on the ext page. The pod was taken from a tree of the so- lled Trinidad cacao growing in the Roseau Valley, Domin- a. It was nine inches long and nearly four inches in ameter at its widest part. The pod was pinched in at the

top, and pointed below, the point being curved to one side. The skin was of a yellowish red colour, it had ten furrows, and the ridges were tuberculated or warty. On opening the pod, the skin or shell was found to be brittle and thin, not being more than from four to five eighths of an inch thick. There were 38 seeds, two being small and inferior, and the remaining 36 were full, round and plump, measuring about an inch and a quarter in length, by nearly three quarters of an inch in breadth. On cutting open one of the seeds longitudinally, the plumule and the radicle and a

The number of seeds.



POD OF CRIOLLO CACAO GROWN IN DOMINICA.

portion of the cotyledons were milky white, and at the upper margins the cotyledons were of a light pinkish colour. On chewing the seed the taste was nutty and slightly bitter with the distinct cacao flavour. The saliva was tinged of a pinkish, and not of a purplish colour as when a bean of the common cacao is chewed. This was a pod of the rea Criollo cacao, one of the best kinds known, and as the othe varieties approach it in type, so are they better in characte and their produce more valuable in the markets.

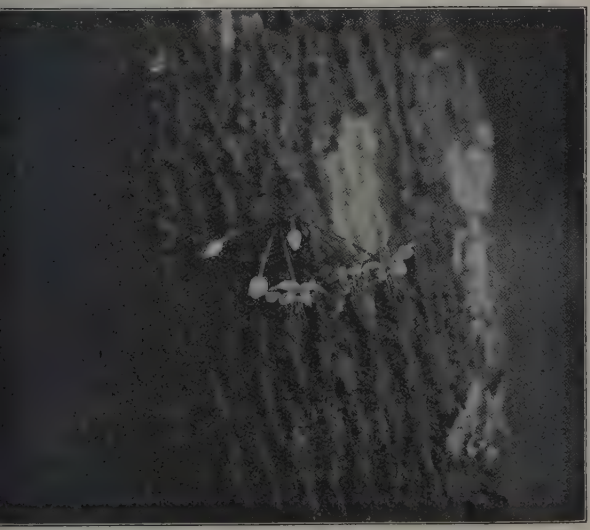
The seeds white internally.

Caraccas cacao.

"Forastero" is a variety now very commonly grown fo commercial purposes; the pods are thick and woody, more or less smooth and furrowed, beans purple, flatter than in "Criollo." There are numerous forms of "Forastero," grading through the "Cundeamor" and "Amelonado" to a small form known as "Calabacillo," now regarded by some authors as a distinct species (*Theobroma leiocarpa*). The

"Forastero" cacao.

beans when fermented and prepared for shipment should be light brown or cinnamon colour for "Criollo" and dark brown for "Forastero." The ideal bean should have the shell a nice bright red, with a slight tendency to purple after fermentation (*q.v.*).

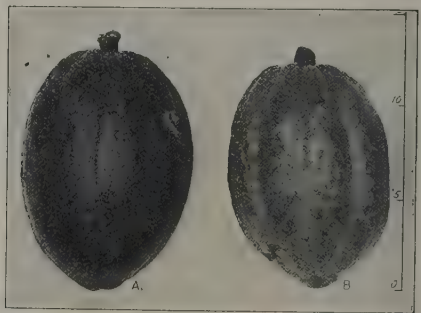


FLOWERS ON THE STEM OF A CACAO TREE.

[*From "Cocoa," by C. J. van Hall.*

SOIL.—The cacao tree has a long tap root and it must, therefore, be planted in deep soil. The best soil of all is that occurring in valleys and undulating lands, along the banks of rivers or streams, and made by the decomposition of volcanic rocks. It will also grow well in loams and the richer marls, but it will not thrive in stiff, heavy clays. The best soils.

TWO PODS OF "FORASTERO" ("AMELONADO").
Type A. Not bottle-necked, blunt apex. Type B. Bottle-necked, pointed apex and deep ridges.



TWO PODS OF "FORASTERO" ("CALABACILLO").
A. Typical "Calabacillo." B. Surface of this type not so smooth and therefore more like "Amelonado."
[*From "Cocoa," by C. J. van Hall.*

CLIMATE.—A warm, moist climate is necessary for the cultivation of cacao, if large crops are expected; but, when the soil is suitable, the tree will grow and give fair returns in a moderately dry place, as is found in some parts of Dominica and Grenada. The ordinary cacao plant will not do well in the mountains above two thousand feet, and even at that height it becomes stunted and does not remain fruitful for many years. The best elevation is from 300 to 500 feet; and, in sheltered situations near the sea shore, good crops are to be obtained, but the tree will not thrive if exposed to the direct influence of the sea breeze. Does not thrive at high elevations.

Cacao will not bear much exposure, and it does not do well usually, in places with a northern or eastern aspect. Sheltered lands and valleys with a southern or western aspect are the best situations to form cacao plantations. Shelter necessary.

PROPAGATION.—Cacao plants are obtained from seeds which germinate readily and quickly; and the seedlings may be raised in nurseries in the same way as coffee plants. Nurseries. Selected pods from the best trees should be picked perfectly ripe, and then be kept for a week before planting, as this favours germination, indeed if left long enough the seeds will push out the radicles whilst the pod is unopened. That part of the seed attached to the stringy centre of the pod is the one to be placed downwards in sowing; and, if the seeds have been already withdrawn from the pod, then they may be sown lengthwise, as there will be a difficulty in finding out the end where the plumule pushes forth. The seeds may be put in the nurseries four inches apart and nine inches between the rows. In a few months' time the plants will be a foot high, and then they can be put out into the fields, care being taken to remove them with a ball of earth around the roots. A better way is to raise the seedlings in bamboo pots or baskets as illustrated on page 148, though the practice of planting at stake, as was described in the chapter on coffee, is, perhaps, the commonest method of propagation, and with How to sow the seeds. Transplanting. Bamboo pots or baskets. Planting at stake.

NEWLY PLANTED YOUNG CACAO PLANTS IN BASKETS, JAVA

proper care it answers remarkably well. Three or four seeds are grown around the stake at distances of nine inches from each other; and, if all grow, the stake will be in the centre, and serve as a mark for the weeders. When the plants are well grown all must be removed except one—the strongest and the best formed plant being left. The plants taken out will do for supplying vacant holes, and they can be transferred on a wet day. Propagation by means of grafting (by approach) or budding has been under experiment in Trinidad for some years, and although it has been demonstrated as a successful method, it is only of recent years that the possibilities of grafting in the development of plantations have been taken seriously. The grafting of old stumps is not recommended; but apart from the grafting of young, vigorous stocks with scions from good bearers, it has been suggested that the "gormandisers," "watershoots" or "suckers"—succulent, erect growths near the foot of the tree recommended in the pruning to be removed—might be used as stocks for budding if it is found that certain trees in an established plantation are unprofitable.

Only one plant to be left.

Grafting or budding.

PREPARATION OF THE LAND.—The land is prepared in the same manner as for coffee (see page 118), but when the forest is cleared, shade belts should be left or afterwards planted in exposed places so as to shelter the cacao trees.

Shade belts.

LINING.—The cacao is a much larger plant than the coffee, and thus it must be planted at wider distances. On rich flat lands, from 15 to 18 feet will not be too wide, but on poorer soil and on hill sides, from 10 to 16 feet will be the proper distance. In very steep places the trees may be planted closer in the descending lines than in the lateral ones; thus, if the lines be 15 feet apart laterally, the trees may be 10 or 12 feet apart in the descending lines, for the branches of the trees above will spread out over those below, and yet allow ample space for light and ventilation. If cacao be planted on rather poor soil, at elevations above 1,000ft., the trees may be as close as ten feet, for they will not grow so large in

Distances.

Close planting.

such situations as in more favourable localities. But on no account must the trees be nearer than eight feet to each other, and if a good planter come into possession of a cacao plantation where the trees are closer, he will at once set to work to thin them out, for in this way, although he will decrease the number of his trees, he will greatly increase the crop.

Thinning out the trees

HOLING.—This has been duly described in the chapter on coffee. Except in the case of rich, friable and well drained soil, holes must always be dug for the plants. To put a cacao seedling into hard, stiff land, without holing properly, is simply to court failure, for the plant will remain with scarcely any attempt at growth; and, if it do not die, it will take many years before it produces any fruit. The holes should be two feet square and two feet deep—that is eight cubic feet of earth must be taken out; if this be done, and the holes be properly filled, cacao can be made to grow on almost any soil that is sufficiently deep. If the digger be driven into the ground at the bottom of the hole, and if it enter freely without touching rock the soil may be considered to be deep enough for the cacao plant.

Holing necessary.

Size of the holes.

TRANSPLANTING OUT.—This must be done very carefully, for the seedlings are extremely delicate, and plants taken from the nurseries will die in large numbers if dry weather come on after planting. It is as well, therefore, to wait for the rainy season before putting out the plants into the field.

Transplanting to be done in wet weather.

SHADE.—The cacao trees when young will not thrive without shade, and when they are fully grown, it is found that they give better crops if shade trees are planted at intervals. For the young cultivation, the banana gives the best shade, and it seems specially adapted for the purpose; besides which, its fruit is valuable, and will give a return from the land whilst the young cacao is growing. The bananas should not be put closely to the cacao plants. The best way is to

Shade advantageous.

Bananas.

place them in the middle of the lines; for, if they are too near the young cacao, their roots do harm, and there is danger of the trees being injured when the bananas are cut, or when their stems are thrown down by high winds. For permanent shade, the immortelle tree (*Erythrina umbrosa*) or the "cacao mother," as it is called, is used in Trinidad; but bread-fruit, bread-nut, trumpet tree, and guango or saman trees may be planted. They should not, however, be closer to each other than 60 feet, and in narrow mountain ravines, where there is natural shade, they may be dispensed with altogether. In such a ravine, on a cacao plantation in Dominica belonging to the author of this book, the shade trees had to be cut out, as they kept back the growth of the plants. In exposed places shelter belts are a necessity; and they should be planted before the cacao. The kind of trees used for these belts may be left to the planter's judgment, care being taken not to select those that impoverish the soil —as hardwood trees do—and to reject all those with branches so brittle that the winds break them easily, and those that spread their roots close to the surface of the ground. Any fast growing tree obtainable in the neighbourhood of the estate may be employed.

Shade trees.

Ravines do not require shade trees.

Exposed situations to be avoided.

WEEDING.—Land under cacao cultivation should be kept clear of weeds; and proper tillage, including suitable cover- or catch-crops, by improving the soil, will do good to the trees. On steep hillsides cutlassing will be sufficient, and on level places an occasional hoeing will be required. When the trees are grown so that their branches shade the land, the weeds will not grow very fast, and, as a rule, they are so loosely rooted that they may be easily pulled up.

Cover-crops.

Cutlassing on hillsides.

PRUNING.—The cacao planter will have to give careful attention to the pruning of the trees if he wishes to get large crops. As the pods are borne on the larger branches, the principle is to develop such branches by judicious pruning, and to see that they are not covered up by a mass of foliage

The necessity of pruning.

The best type of a cacao tree.

and small twigs. A typical cacao tree should have one stem giving off at a few feet from the ground three to five branches which spread in an open manner, and are free from leaves except at the tops—thus the leaves shade the open inner portion without interfering with a free circulation of the air.

Only one main stem allowed to grow.

If the young plants throw out more than one main stem, the surplus ones must be pruned off; and, after the lateral branches are formed, no upward prolongation of the stem must be allowed to grow. If the tree be left alone these upward growing branches will come off from the stem, just below the laterals, in the form of suckers, and to leave them on is to cause the strength to be taken from these fruitful laterals, as well as to allow the trees to run up, perhaps, for thirty feet or more, thereby causing much trouble in picking the pods. When the suckers are pruned off, fresh ones will grow after a short time, so that the trees will require frequent attention until they are mature, when the tendency to throw out suckers will be stopped. In gathering the pods, the suckers may be taken off at the same time, but the tree should not be pruned in the flowering season.

Suckers to be removed.

The trees not allowed to fruit when young.

The first flowers, under favourable conditions, will come out at the third year, but as the tree is not mature then, the should by no means be allowed to produce pods, otherwise the plant will be so weakened by the fruiting that its growth will be greatly checked. The first flowers, therefore, should all be rubbed off. After waiting three years for produce it is no doubt rather disheartening to be compelled to prevent fruit from forming, but it must be done if the planter look to the future big gain and not the present small loss. Generally crops cannot be expected from cacao under five years.

Importance of manuring.

MANURING.—Unless in the case of sickly plants on poor soil, the trees will not require manuring until the crops are taken off; when, as may be imagined, it will be necessary to restore to the soil, in a cheap way, what has been removed in the valuable produce. A good deal will naturally depend on

the nature of the soil and the yield of the trees. Should crops, which were abundant, be found to be falling off, it is an indication that manure is necessary ; and, in Chapter VII. of the first part of this book, it has been seen that continual cropping must, sooner or later, exhaust the soluble constituents of the soil.

Continual cropping exhausts the soil.

CATCH CROPS.—These may be raised between the cacao trees, for the first few years with advantage, for the light shade given by them to the young cultivation is beneficial. Tanias and cassava are especially suitable for this shade, and they will give some return to the planter. When the cacao trees are grown, and begin to bear, all temporary shade plants must be cleared away.

Tanias and cassava.

ENEMIES TO THE CACAO TREE.—The principal enemy to the cacao tree is the grub of a beetle, which bores holes into the stem, thereby killing it, but the hole is easily recognisable and the insect may be dug out and some earth or clay or wood ashes rubbed into the place; or, better still, the wound may be painted with tar. Hurricanes are peculiarly destructive to the cultivation, and especially to the young trees. The enormously powerful gusts of wind break down the branches in all directions, and if the roots become shaken, as those of nearly all the young plants certainly will be, the trees will dry up and look as though blasted. Much of the young cacao cultivation was killed out in this way in Dominica by the hurricane of 1883, and many persons imagined that the trees had been blasted by lightning. As cacao plantations are damp and shady, mosses, ferns and other epiphytes, are very liable to grow on the stems and branches of the trees, but they must be removed at once, as they will otherwise injure the trees and prevent the delicate flowers from coming out properly.

The borer.

Hurricanes.

Blasted treees.

Epiphytes to be removed.

CROPS.—Returns from a cacao plantation cannot be expected until five years after planting, and it will not be in

Crops in five years.

full bearing before from seven to ten years. A few trees may bear earlier than five years, but these are very favourably situated and they are exceptions to the rule. The trees bear nearly all the year round, but there are two principal crops—one from April to June, and the other from November to January, the latter crop being much the more abundant of the two. The crops are usually termed Easter and Christmas, after the seasons of the year during which they are gathered.

Two crops annually.

The average yield of dry cacao from each tree, of course, varies very much. The limits may be said to be from a pound and a half to eight pounds per tree. On the rich, alluvial lands of Surinam, from eight to nine pounds per tree are said to be obtained; but, in the bad cultivation of West Indian peasant proprietors, it is doubtful whether a pound per tree is got.

Return per tree.

The pods must not be picked until they are fully ripe. A little observation and experience is all that is necessary to tell at once, by the look, whether the pod be ripe or not. If it be within reach it may be tapped with the knuckles or the handle of a knife, and if it sound hollow it is ready for picking. As the varieties of cacao vary so much in colour, no precise rules can be given as to the peculiar shade of a ripe pod. The fruit must be *cut* from the tree with a cutlass, cacao knife, or a cacao hook; and on no account ought it to be twisted or torn off the tree. The cut should be clean, and as close to the pod as possible. For, if a tree be examined it will be found that at the base of the stalk of the pod there is a little swelling, called the *eye*, and it is from this part that the flowers for the next crop will come out. If, therefore, the eye be torn away, no more pods can come out from that part of the stem; and by a non-observance of these facts many cacao trees have been ruined, the crops have failed, and the planter has thought that something was wrong with the soil! The cacao hooks are made in many different shapes, they are fixed on to a bamboo rod, and used

Only ripe pods to be picked.

Pods not to be torn off the tree.

Importance of care in picking.

Cacao hooks.

CACAO TREE: CUTTING PODS.

[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

to gather the pods out of the reach of the knife. The stalk of the pods can be cut by these hooks with either a thrusting motion or a pulling jerk. Some of them have a chisel at the end, and all the hooks are sharpened on the concavity like a sickle.

Breaking the pods.

The pods having been gathered, they are placed in heaps under the trees and they may be broken at once or left for a day. The seeds or beans or nibs—they are called by either of these three names—are then taken out of the pods, which are either opened with a cutlass or broken by knocking them against each other or on a stone. The seeds may be *drawn* with the fingers, or by means of a wooden spoon, and at the same time the white fibrous tissue is taken away. This stringy stuff and the broken pods should be put in heaps to rot for manure, or be spread over the roots of the trees, or, better still, be buried between the trees, and in this way something will be given back to the soil.

Drawing the seeds.

Shells used as manure.

FERMENTING.—The beans are now carried away to the cacao house for the purpose of being made to undergo a *sweating* or *fermentation* process. This is a very important matter for the planter, inasmuch as on its proper performance depends, to a great extent, the value of his produce. In some places the cacao beans are simply dried as soon as they are taken out of the pods, and the cacao thus prepared is sold or shipped to the markets. But it is very inferior stuff with a bitter, unpleasant taste, and it fetches the lowest prices, and gives a bad name to the bulk of the cacao.

Importance of proper fermentation.

Sweating is simple and inexpensive. It may be done in boxes or barrels or in an air-tight room. The cacao is put into a receptacle, usually made of wood, which may vary according to convenience—a useful size being large enough to contain approximately 500 [1] to 3,000 lbs. (4 × 4 × 4

How to ferment the beans.

[1] 500 lbs. of beans is perhaps the smallest quantity that could be put to ferment effectually, and allowing 50 lbs. of wet beans to the cubic foot, a box of the dimensions given would also conveniently ferment the larger quantity.

[*Photo, Hisgen.*

FERMENTATION BOXES, PLANTATION "DJATI ROENGGO," JAVA.

The variety cultivated here is the "Forastero" ("Djati Roenggo Hybrid"). The fermentation lasts 3½ days, and the beans are turned over into the next box every day. From the last box the beans are shovelled into the washing basin.

[*From "Cocoa," by C. J. van Hall.*

feet—with a covering of banana trash and provision made for the juice to escape below. In Java, fermenting boxes are arranged in a series of steps so that the cacao is easily transferred from the higher to a lower, and the beans may be shovelled from the last box into the washing basin or tank, covered with plantain leaves and boards put on the top. The beans are left to ferment for about three days, when they are removed to another receptacle, closed up again and allowed to sweat for three days longer. The temperature

may have risen gradually to about 115° F. after three days' fermenting. The object of opening the cacao is to cause the fermentation to be equal; for, in changing it, that which is on top at first becomes the bottom layer in the second receptacle, and thus uniformity is secured. When the cacao is sweated in heaps in a closed house, the heaps can be turned over or stirred up on the third day; and, in this way, the outside beans will get their due turn of the full fermentation process. Some fine kinds of cacao do not require to sweat so long, but experience alone can determine this point. "Criollo" may take only one or two days to ferment; the longer period given would apply more to "Forastero." In the fermentation the first stages of the germination of the seed go on. The moisture, warmth, and a certain amount of air, cause the seeds to swell, carbonic acid is given off, and the food stored up in the seed for the use of the embryo is converted into soluble matter, and this accounts for the modification of the bitter taste of the raw bean brought about by the sweating process. Various hypotheses, however, have been advanced from time to time as to changes in cacao on fermentation; but so far nothing complete appears to have been established. The subject is discussed in the works mentioned below.

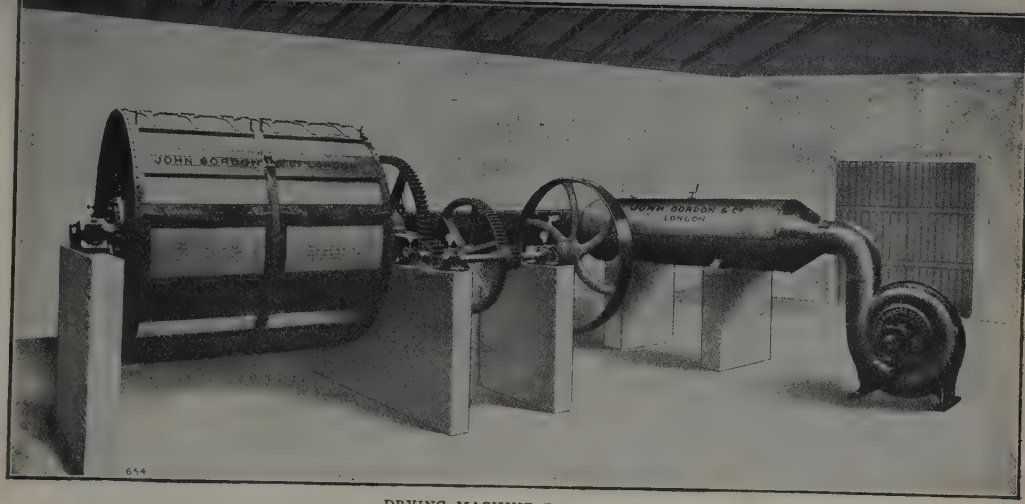
The heaps to be turned.

Time taken to ferment varies.

Drying the beans.

CURING.—The beans having been properly sweated they are to be dried ready for shipment, and this drying process is termed curing. The drying may be done in wooden trays, or on paved or cemented platforms called *barbecues*. In Trinidad, the trays are fixed, and a roof on rollers is placed over them. When the sun is out the roof is rolled back and the cacao is exposed; during rain and at nights the roof is rolled over the trays, and in this way time and labour in carrying out the trays and taking them in again are spared. On the Malgré-tout estate in Dominica the roof is a fixture, and large trays on rollers are pulled out like the drawers of a clothes press. The sweated beans are spread out thinly, well rubbed and exposed to the sun in the morning, and at mid-day they are put back in the sweat-

Drying houses.



DRYING MACHINE FOR CACAO.

After fermentation the beans are put into a rotating drum through which hot air is forced by a powerful fan. The beans, by the slow rotating of the drum, are thus dried uniformly, and polished. The air is usually heated by passing through a heater as illustrated, in which the exhaust steam from a steam engine is employed, or failing this by direct fire-heat. The capacity is 4,000 lbs. of wet cacao, which can be dried in from 24 to 30 hours. They are also made with a capacity varying from 2,000 to 10,000 lbs. of wet cacao.

ing boxes or houses to undergo another partial fermentation, for if they be dried straight off they will deteriorate in value.

When cured.

The second day they are kept longer in the sun, and the third day they are kept out as long as the sun lasts. They are put out on succeeding days until they are thoroughly dry, which is told by their producing a crackling sensation when pressed between the thumb and forefinger. In Ceylon the cacao, after being fermented, is well washed to get rid of the mucilage, and it is then carefully and gradually dried so as to produce plump, clean, and attractive-looking beans. The Ceylon cacao thus cured fetches the highest prices in the London market. Machines for drying the beans may be obtained (see page 159).

Drying Machines.

How to clay the beans.

CLAYING.—Sometimes the cacao is *clayed*, and this is done in the following manner: When the beans are removed from the sweating boxes, they are sprinkled with red clay that has been dried and pulverised. On the second day the same process is gone through if the clay has not tinged all the beans. Then the beans are rubbed between the hands for an hour or so in order to clear away the surplus mucilaginous matters. The drying is afterwards finished as usual. Clayed cacao has a reddish appearance, and the colour is uniform, and it usually fetches high prices in the markets. The principal supply of clayed cacao comes from Venezuela and is usually known as Caraccas cacao. It is not recommended in English colonies to clay any cacao. If improvement is sought it should be in the direction of Ceylon cacao.

Mildew.

The rubbing process above described may also be employed when the cacao becomes mouldy in very wet weather, it cannot then be sunned sufficiently, and, for this reason, on large estates, it is sometimes necessary to effect the drying, with artificial heat, in a kiln.

The chief commercial sources are Gold Coast, Brazil, Ecuador, St. Thomé, Trinidad, Venezuela, Nigeria, Ceylon, Java, &c., the prices ruling in Oct. 1926 being Accra 50-55*s*., Bahias 55*s*. Guayaquil 82*s*., St. Thomé 55*s*.,

DRYING-FLOORS WITH MOVABLE ROOFS, AS ADOPTED IN TRINIDAD.
[*From "Cocoa," by C. J. van Hall, after Fauchère, "Culture pratique."*

HEALTHY CACAO UNDER "KAPOK," IN JAVA.
[*From "Cocoa," by C. J. van Hall.*

Trinidad Mid-Red 70–75*s*., Ceylon 80-85*s*., and Grenada Fine 65*s*. per cwt. The world's production exceeds one thousand million lbs., of which the Gold Coast accounts for nearly one-half.

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CHAPTER IV

TEA. *Camellia Thea*

THE tea shrub, of which there are many varieties, is a native of China, Japan, and North India. It has been cultivated from time immemorial in China and Japan; and, in

Habitat of the tea plant.

TEA (*Camellia Thea*).

ecent years its cultivation has extended rapidly in India nd Ceylon. The plant grows very well in the West Indies, nd there is a small occasional output from Jamaica.

It thrives in the West Indies.

The chief countries of production at the present time are British India, Ceylon, Java and China. Natal, Nyasaland and Kenya are developing as promising sources of supply in Africa, and cultivation is well established in Hong-kong, Australia and Canada. There are two principal varieties of tea under cultivation—the "China" and "Assam," and a third 'Assam Hybrid" might be included. Various blends of tea are sold; but broadly they are classed as "China," "Ceylon" and "Indian," or by name of the country of production.

Varieties.

The best soils.

SOIL.—The best soil for tea is a light loam, with an abundance of vegetable matter. As the plant has a long tap root the soil must be deep, and it must also be well drained, for stagnant moisture is fatal to it. A subsoil of reddish clay is considered to be not unfavourable to the plant, but it does not appear to require much lime. Tea, however, is very hardy, and it will grow well in many other kinds of soil, provided there be an abundance of humus—which can be supplied by green crop manuring.

The plant a hardy one.

Chinese tea.

Heavy rainfall necessary.

Tea in Jamaica.

CLIMATE.—To grow tea, it is not necessary to have one uniform climate, for the shrub accommodates itself to many different elevations and degrees of temperature. The Chinese variety, however, thrives best in the hills up to 5,000 feet elevation, and the Assam kinds prefer low valleys and plains where the air is hot and moist. A good rainfall is necessary if large crops be sought for. In Assam the temperature ranges from 50° F to 96° F. and the rainfall is from 100 to 120 inches per annum. Morris said, in regard to Jamaica, "for the hills, the tea plants already established here, being the Chinese kind, are admirably suited; but for the parish of Portland, with its warm, moist climate and splendid rich valleys, the Assam kind appears to be more suitable." In general suitable areas are found within the tropics at 3–6000 feet or in the sub-tropics under a rainfall of at least 60 inches evenly spread over the year.

The plants must be protected from strong winds; and, in exposed situations, shelter belts ought to be planted. Shelter belts.

PROPAGATION.—Tea is propagated from seed, which may be sown in nurseries or at stake in the fields. The seeds are enclosed in hard coverings, and some planters advise that they should be put in the sun until the shells split, as, in this way, germination is more rapidly effected, but the seeds may be sown as they come from the trees. They may also be raised in bamboo pots or baskets as advised for coffee. Sowing the seeds.

The seeds must always be fresh when they are planted, for they contain a large quantity of oil which becomes rancid if they be kept out of the ground. They may be preserved, however, for a time, in dry earth, and when required may be sent long distances in this manner. The seeds are sown four inches apart in the beds, six inches between the rows, and at a depth of two inches below the surface. When transplanted, care should be taken to remove a ball of earth with the roots, for the seedlings are delicate, and otherwise soon die out. Seed-bearing plants are usually grown apart, but sometimes seed is selected from bushes in the plantation. Seeds must be fresh. Nurseries.

PLANTING.—The land having been prepared in the usual way, as described in the chapters on coffee and cacao, and pickets having been set at distances of four feet by four feet, or four by five, or five by five, according to the nature of the ground, holes must be dug, but they need not be so large as for coffee and cacao. In planting out the seedlings from the nursery, which may be done as soon as they are from nine to twelve inches high, particular care must be taken not to injure, or double up the tap root. Distances. Transplanting.

CULTIVATION.—The tea "gardens," as they are called, must be kept free from weeds, and the soil is to be loosened occasionally between the rows. All weeds should be buried; for, as the tea plant requires a vegetable soil, green crop Green crop manures.

TEA PLANTATION, CEYLON. PICKING LEAVES.

[From the Collection, Royal Botanic Gardens, Kew

manuring is very beneficial. As the plants are set close together in the fields, catch-cropping cannot be recommended, for otherwise the permanent cultivation will suffer merely to benefit the temporary one. The plants will require much attention for the first two years, by which time they become firmly rooted, and then they are very hardy.

PRUNING.—When the plants begin to grow, they will throw out many branches, and when these attain to the length of six or eight inches it will be well to pinch off the ends, so as to induce a branching and bushy habit. This pruning process, somewhat similar to the "handling" of coffee, may be continued until the third year, by which time the plants should be about two feet high.

Prune to induce a bushy habit.

The tea of commerce is simply the dry and prepared immature leaves, in fact the ends of the shoots advised to be plucked off in the preceding paragraph; the object of pruning, therefore, is to force the plant to produce successive growths of new shoots—and these are called *flushes*. All old wood, and badly branched stems, should consequently be cut away in the manner described in the chapter on pruning in the first part of this book. No precise directions can be given, for it is simply a question of judgment on the part of the planter. Tea bushes should not be allowed to grow more than four feet high. Once a year, during the resting period where the seasons admit, is recommended for pruning; but the periods may extend to two years or more, depending on local conditions, elevation and experience. Usually the pruning knife should be sufficient, the saw being used only in extreme cases to remove old branches.

Tea of commerce got from the young shoots.

Bushes to be topped at four feet high.

Tender branches pruned off may be buried between the rows before they wither, and this is important as they form valuable manure.

Prunings to be buried between the trees.

CROPS.—These commence at the third year and go on increasing up to the sixth year, when the plantation may be considered as giving a full harvest of leaf in the course of a growing season. In the early stages the crops may be small,

Return per acre.

but when the estate is in full bearing an average of 250 l
of tea to the acre is obtained. The yield depends natur
on the number of *flushes*, "of which there are probably
more than ten to fifteen in the year from even the strong
bushes, although a garden has to be plucked all round ab
thirty or thirty five times in the course of the year as ev
shoot is not ready for plucking at each time of going round

The leaves to be tender when picked.

The part picked consists of the three end leaves with the b
and stalk; the leaves and the stalk must be tender,
otherwise the tea made is coarse and of little value. T
end of the branch is simply *nipped off* just beyond a bu
this is usually done in tea countries by women a
children, who after a little practice become very expert.

MANUFACTURE OF THE TEA.—A flush having appear
on the bushes, and the young terminal shoots having be
picked, the next thing is to manufacture the tea, which pr
cess usually occupies only a few days, and may be done wit
out the aid of any expensive machinery, if the cultivati

Machinery advisable on large estates.

be on a small scale. It is, however, advisable on lar
estates and ensures manufacture in unfavourable weather (s
pages 173-180). There are four processes to be undergon
namely—1. Withering. 2. Rolling. 3. Fermenting. 4. Firin

WITHERING.—The leaves are spread out in the sun or o
shelves in well-ventilated sheds for about two hours, b
which time they will become softer and more pliable—in fac

Leaves withered in the sun.

they will be *withered*, a term known to every one as expres
sive of the drooping and softening of leaves and flowers cu
and kept in dry places. The withering prepares the leave

Flavour of tea depends on juices.

for rolling; and by partly drying the cells of the epidermis
it assists them to retain the juices on which the flavour o
the tea depends. When the leaves are gathered in we
weather, the withering may be done in an iron or tin pan
under which fire is put so as to cause moderate heat. This

[1] Bald, "Indian Tea," gives 2½ ozs. of tea per annum for each bush
(the estimate of 250 lbs. would therefore mean at 5 × 5 ft. = 1,742
plants, or 425 lbs. at 4 × 4 ft. = 2,722 plants per acre).
[2] *Ibid.*

pan will be described later on. The leaves may also be withered by spreading them thinly on the floors of building.

ROLLING.—This process is an important one, and by it the leaves are made to have that twisted shape so well known to all. The object of rolling is not, however, to twist the leaves, for that is simply an accident of the process, it is to press out the bitter juice and to prepare the leaves for the stage of fermentation. In China the process is always done by hand, but in India and Ceylon special machines are used. The rolling by hand, however, answers the purpose quite well on a small scale.

Rolling presses out the bitter juices.

How the rolling is done.

The rolling is commonly done on a smooth table, covered with the Indian matting used for floors, in the following manner: A ball of withered leaves is taken in the hands and rolled backwards and forwards, or from side to side, considerable pressure being exerted at the same time. This causes the leaves to have a soapy feel, and it twists them up in various ways. When juice exudes and the leaves have the proper twist the operation is completed. A hard working man can roll 30 lbs. of leaves per day.

FERMENTING.—The rolls may be open so as to pick out red and ripe or coarse leaves, or they can be put into baskets or heaped up on the floor until they ferment, in which case the bad leaves are picked out afterwards. The fermentation is sometimes dispensed with, but it is an important process as it develops the peculiar flavour of the tea. No particular time can be mentioned as the proper period for the fermentation process, which may last a few hours. It is entirely a matter for experiment and experience.

Red and coarse leaves to be picked out.

Fermentation develops the flavour.

FIRING.—This term is applied to the last stage in the manufacture, because the leaf is usually dried with artificial heat, in open pans or in one of the many machines, called *driers*, used for the purpose in tea countries. But the process

Firing or drying.

How to dry the leaves.

can be effected by the heat of the sun, the only thing necessary being that the rolled leaves are spread thinly on mats, or on clean trays. With a bright, hot sun the leaves will dry in a little more than an hour, but they will require an occasional stirring in order that the lower layers may dry as quickly as the upper ones. In firing on a small scale, an iron or tin pan, three feet in diameter, seven inches deep, and flat at the bottom, may be used. The fire is made with charcoal, and the heat must be just too much for the hand to bear, say from 180° F. to 200° F. The leaves are put in the pan as soon as fermentation is complete, and they are stirred until they are perfectly dry, which happens very soon. Great care must be taken to prevent the heat from being too great, otherwise the leaves will be charred, and the tea will be ruined.

The leaves to be stirred.

Heat not to be great.

Great care in preparation necessary

BULKING.—The dry tea must now be prepared for the market, and this is an important operation, for its condition, and therefore its value, depends greatly on the care it has received after it has been manufactured. On large plantations in the East, the tea is sorted into various classes as we shall see later; but where small crops are produced, it is advisable to ship the tea *unassorted*—it must, however, be free from dust and unrolled leaves. The dust is easily removed by a slight fanning operation, in the same way as the parchment is winnowed from coffee, care being taken that the wind does not blow away the finer parts of the tea; and the large leaves, that have come out unrolled, are broken up and added to the bulk. In India and Ceylon they are cut up by machinery and sold as "broken leaf." The term "unassorted tea" does not mean, however, that the produce is packed in the chests or boxes anyhow, for the tea must first be *bulked*, that is to say, it must be carefully mixed so that each chest contains tea exactly similar in character. Bulking is done by machinery on important estates in the East, but on a small scale it may be effected in the following manner. A

Sorted and unassorted teas.

Contents of different chests to be similar in character.

large square box is raised on posts some feet above the ground, and at the bottom of the box a square hole is made, and so closed with a sliding trap door that the outlet can be enlarged or reduced according to necessity. The door being closed, the tea is put into the box in thin layers—one quality on the top of the others. The trap is then opened, and the tea runs out from the top taking a portion from each layer in its downward course. So as to ensure that all the tea runs out evenly, it will be well to make the bottom of the box slope slightly towards the central aperture. The principle of this plan is the same as that of the sand-glass. It is very simple and at the same time efficacious. How the tea is bulked.

SORTING.—On large tea plantations the tea is sorted into various classes. Before tea cultivation was taken up in India, the greater part of that consumed in the world came from China, and it was believed that each kind was the produce of a different variety of the tea plant. Afterwards it was discovered that all kinds of tea came from the same bushes, the different qualities being produced mainly by sorting operations. Thus *pekoe* is produced from the delicate opening bud of the leaf, and it gives the strongest tea in the cup. *Pekoe Souchong* is the next finest kind. *Souchong* is a tea somewhat coarser in appearance, and in *Congou* the leaves are larger still. On a small scale, tea may be sorted on trays by boys and girls, whose quick fingers can accomplish a good deal of this light work in a short time. Whilst the various qualities of teas are separated, all red leaves, and useless and foreign matters, must be picked out, as otherwise the tea would be deteriorated. Different varieties of tea. Sorting on a small scale.

The various classes of tea may also be separated by sieves with different sized meshes; and, when the process has to be gone through on a large scale, machinery is employed. Sorting with sieves.

The tea industry of India and Ceylon has become so large and important that anything money and skill could accomplish has been utilised in producing machinery as perfect as Machinery in the East.

possible, with the result that the tea leaves brought fresh from the fields of the extensive tea gardens in these countries, are converted, in a short time, into the various grades of tea entirely by mechanical contrivances (see pages 177–8).

Tea to be packed without delay.

PACKING.—The bulking and sorting should be done as soon as possible after the tea has been manufactured, and it should be packed before it has had a chance to absorb any moisture. When, however, this cannot be done, the tea should be slightly fired before packing to ensure its perfect dryness. It is usually packed in chests lined with lead, great care being taken that there are no holes in the lead lining, and that the top is soldered down so as to exclude all air. About a fourth of the quantity of tea is put in and pressed down with a board until it is quite firm, another fourth is then put in with the same precautions, and so on until the box is filled.

Tea chests

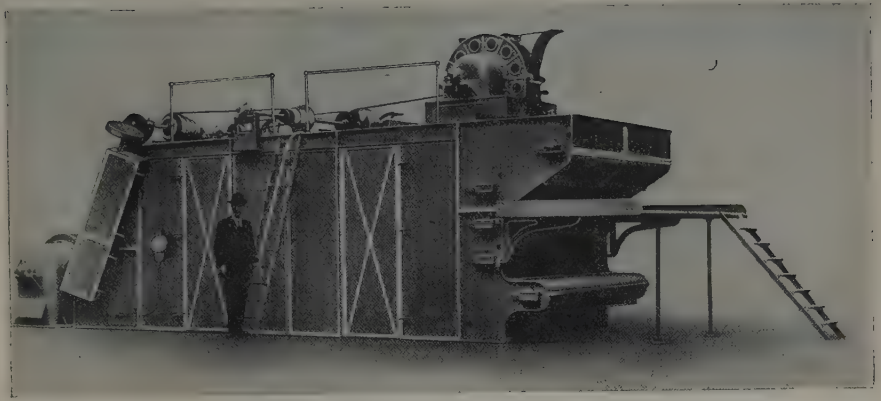
Packing to be done carefully.

The packing machines may vary—a modern one is illustrated on p. 180—the mechanical principles of which admit of the tea being quickly and evenly shaken down and closely packed to the fullest capacity of the chest.

The packing cases are made of different woods, chiefly of local origin. Amongst typical woods in India and Assam are "Simul" (*Bombax malabaricum*), "Toon" (*Cedrela Toona*), "Mango" (*Mangifera indica*) and *Duabanga sonneratioides*. Ply-wood made in England is also recommended.

Trade and market prices.

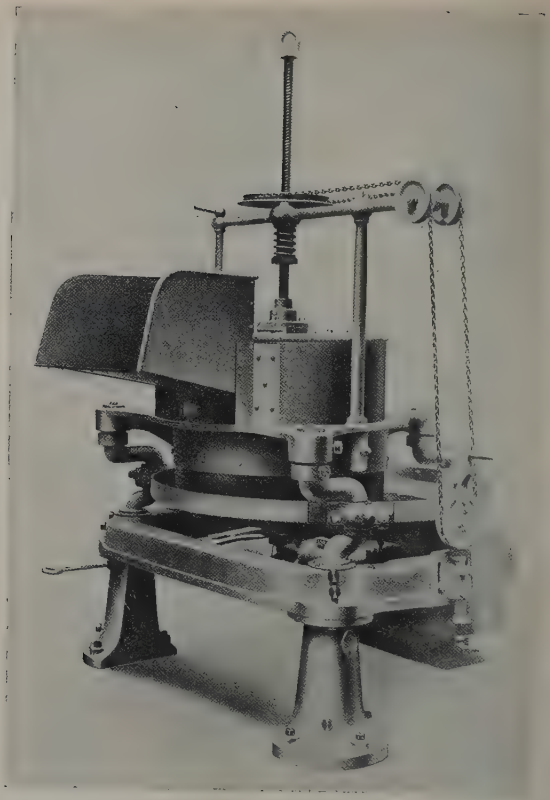
As showing the immensity of the trade in tea, the world's production is upwards of 800,000,000 lbs. a year, the British Isles alone taking approximately half this amount, and the stocks in London at any one time may lie between 100 and 200 million pounds. The prices per lb. average at the present time, wholesale—20*d.* for China, 19*d.* Ceylon, 18*d.* Indian, 15*d.* Java, and 16*d.* for Nyasaland.



TEA LEAF WITHERING MACHINE.

Made in two sizes: (1) 9 ft. wide, (2) 6 ft. wide. Approximate output: (1) taking about 1,500 lbs. of fresh leaf, will produce 1,200 lbs. of withered leaf or 4 rolling table charges per hour; power required, an average of 12½ b.h.p.: (2) taking about 1,000 lbs. of fresh leaf, will produce 800 lbs. of withered leaf or 2½ to 3 rolling table charges per hour; power required, an average of 5½ b.h.p. There are two fans, one to equalise interior pressure and the other to extract moisture. The trays travel on "roller type" chains.

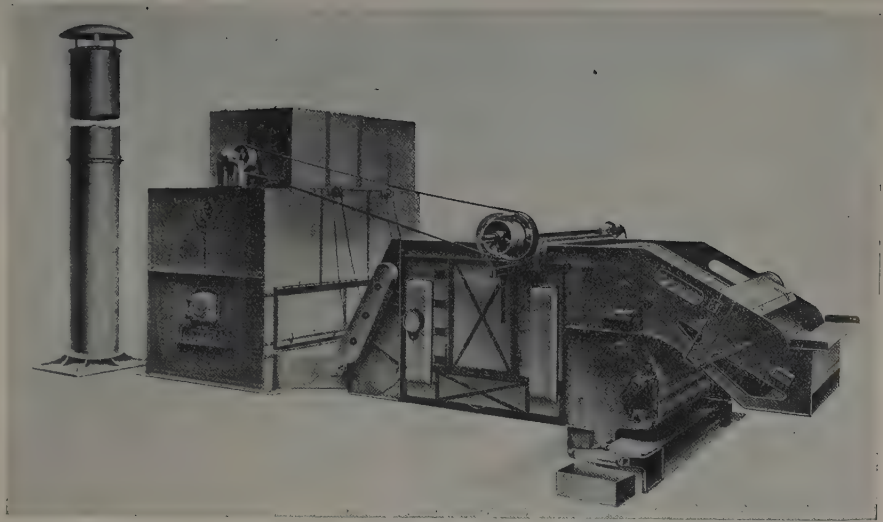
[*By courtesy of Messrs. Marshall, Sons & Co., Ltd.*



TEA ROLLING MACHINE ("DOUBLE ACTION").

Capacity about 360 lbs. of withered leaf per charge. Driving power varies according to the rolling pressure—4 or 5 b.h.p. for light or ordinary rolling, and up to 12 b.h.p. for hard rolling. Speed, 140 revolutions per minute. The machine has pulleys 24 ins. diam., 5-in. face for 4-in. belt. A trolley in redwood or teak can be supplied.

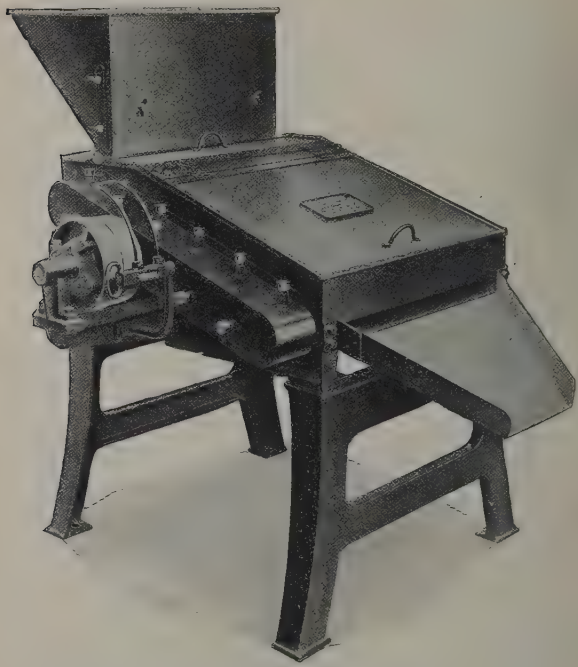
[*By courtesy of Messrs. Marshall, Sons & Co., Ltd.*



TEA DRYING MACHINE ("TUBELESS EMPIRE").

Made in (1) 6 ft., (2) 4 ft. sizes. Approximate capacity 400 and 265 lbs. of dry tea per hour.

[*By courtesy of Messrs. Marshall, Sons & Co., Ltd.*



TEA STALK EXTRACTOR ("BATEMAN").

Designed to reject all large stalk and to separate marketable leaf into two grades. Capable of dealing with 400 lbs. of stalky tea per hour.

[*By courtesy of Messrs. Marshall, Sons & Co., Ltd.*

TEA SIFTING MACHINE ("ROTARY").

12 ft. long, 4 ft. in diameter; driving pulley, 24 ins. diameter by 3¼ ins. wide; width of belt required, 3 ins.; speed, 70 revolutions per minute. Built of wrought iron and pitch-pine.

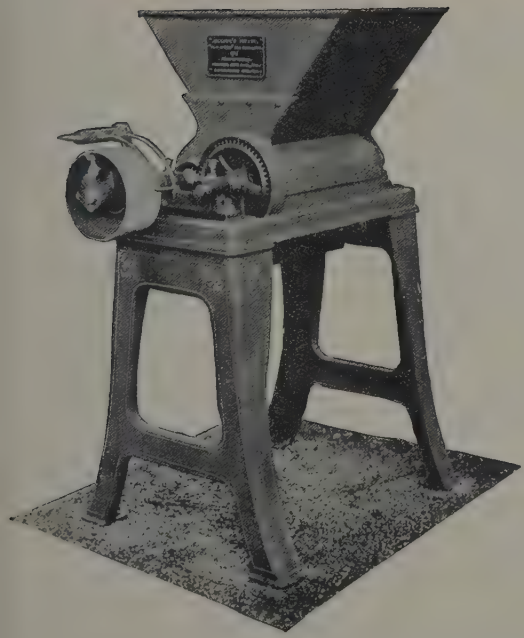
[*By courtesy of Messrs. Marshall, Sons & Co., Ltd.*

N

TEA SIFTING MACHINE ("MAGIC").

This machine standardises the gradings: its action passes the bulk of the tea through with a minimum of friction, thus avoiding production of dust and consequently not greying the leaf. Five grades of tea are obtainable.

[*By courtesy of Messrs. Marshall, Sons & Co., Ltd.*



TEA BREAKING AND EQUALISING MACHINE ("CLIP-ACTION").

With rollers 18 ins. wide, capable of breaking and equalising 1,200 lbs. of tea per hour. Nominal power is required. The driving pulley is 9 ins. diam. by 2¼ ins. wide, and the speed is 280 revolutions per minute.

TEA PACKER ("BRITTON").
Made to pack one or two chests at a time. A hopper can be fitted to facilitate feeding. Nominal power only is required to drive the machine.

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CHAPTER V

SUGAR CANE. *Saccharum officinarum*

Sugar in the West Indies.

UNTIL within recent years, the greatest attention of West Indian agriculturists has been directed towards the production of sugar, which has been, in most instances, made on estates of considerable size employing a great number of labourers. Of late, however, the increased production of beet root sugar (the export of which from foreign countries has been fostered by the granting of bounties), has caused such a decline in prices as to make the cultivation of the cane and the manufacture of sugar, operations attended with but little profit.

The sugar bounties.

Low prices.

Sugar does not pay on a small scale.

The smaller sugar planters have been in most cases compelled to give up the production, and it would appear that sugar can now be made to pay well only when the manufacture is conducted on so large a scale as to require enormous expenditure and very complicated machinery. The system of *usines*, or *central factories*, is being introduced into various parts of the West Indies, and it promises to do much good, in a general way, to those tropical planters who, without much capital, are desirous of cultivating the cane. The usines buy the canes from planters at remunerative prices, and so the agriculturist has only to confine his attention to proper agricultural matters. This is as it should be, for the double system of carrying on the businesses of a cultivator and a manufacturer, is not likely, in these days, to be followed

Central factories.

Planting and manufacturing incompatible.

with success. To expect the English farmer to raise corn and then to make it into flour and bread, would be regarded as absurd. The farmer is the cultivator, and he confines his attention to matters agricultural; the miller is a manufacturer, and it is for him to prepare what the farmer has grown. The same argument applies to the West Indian sugar planter. He should be content to raise the canes on his land, and to allow the manufacturer to make the sugar. The planter will then raise better and more abundant crops, and the manufacturer will make better and cheaper sugar. In a large factory, scientific matters can receive due attention, and the management must be cheaper and more effective than it can possibly be in any of the many small "sugar works."

Advantages of the usine system.

Economy and efficiency in the management of the central factories.

SOIL.—The sugar cane will grow upon almost any soil. Clays, loam, marls, and calcareous soils, are all suitable, more or less, for cane cultivation. Indeed, considering that canes are grown in all the principal West Indian colonies, with their wide diversity of soils, one might feel inclined to come to the conclusion that the nature of the soil was of no account in the cultivation. And neither was it of great moment when large profits were made by the sugar planters, but now that such low prices are got for the produce, the canes can be cultivated profitably only on land that is best suited for them. Rich, porous clays, and alluvial soils on low lands through which rivers run, are the most favourable for cane cultivation, with the exception, perhaps, of loams formed by the decomposition of volcanic rocks. Such a soil as the last mentioned is found in St. Kitts, and sugar can be produced in that island cheaper than in any other part of the West Indies.

Most soil suitable.

Large profits of former days.

The best soils.

The soil of St. Kitts.

Lime is a necessary ingredient in all cane lands, and thus when there is a deficiency of it in the soil, it must be added as a manure. A writer on the sugar cane says, "Lime is beneficial to almost any soil, particularly new, and especially where the salts of iron are found:" but, of course, this does

Lime in the soil a necessity.

The soil of Barbados.

not refer to soil where lime is found in quantity, as in the marls and calcareous soils. In Barbados, where the soil is peculiarly adapted to the sugar cane, lime exists in considerable quantity, for nearly the whole island is of coral formation; and, in parts of Antigua, some of the rich cane lands have been formed by the decomposition of a kind of limestone.

The soil of Antigua.

CLIMATE.—The sugar-cane is essentially a tropical plant; it will grow well in sub-tropical climates, but it does not there give anything like the return that it does in the tropical zone.

A hot moist climate the best.

A hot, moist atmosphere, alternating with periods of dry weather, such as is found on the plains and in the valleys of the West Indian colonies, is the typical climate for the cane.

A lowland plant.

It does not do nearly so well in the hills as it does in the lowlands, and when planted in the mountains it takes a long time to mature and ceases to give remunerative crops.

Marine climate.

Moderate sea-breezes are not inimical to its growth, and for this reason alone cane cultivation is eminently suited to the West Indian islands where the climate is a marine one. Indeed, on the windward coast of the islands, where the land is exposed to sea-breezes bringing in air laden with saline particles, scarcely any cultivated plant but the cane can be grown.

Cane plants.

PROPAGATION.—The cane is propagated entirely by cuttings, for, although the plant flowers, it rarely bears seed. These cuttings are called *plants*, and they consist of the two or three upper joints of the cane. Each joint contains an eye, or bud, from which shoots run up to find air and light, and roots descend into the ground, in much the same way as

Good seed.

occurs in the case of the germinating seed. It has been shown, in the first part of this book, that a good planter, in order to obtain the best and largest crop possible, where propagation from seed is concerned, should select the finest

Improvement of crops.

fruit, and the largest seed from that fruit. By a close observance of this rule, European and American agriculturists have improved grain, root crops and fruits immensely. One would

naturally conclude therefrom, that the sugar-planter, in order to increase the returns from his fields, would be extremely careful in the selection of his "cane plants"—which are, as we have seen, very similar to seeds in their mode of growth. But, strange to say, many sugar planters have paid no attention to so important a matter, and they invariably obtain their plants from "thrown up or exhausted fields." If the sugar planters had taken as much care to improve the quality of their canes, as the European and American horticulturists have done to improve their fruit trees, by this time the sugar-cane would have been so much improved that its greatly increased yield would have preserved the industry from much of the misfortune that has come upon it.

Care in the selection of cane plants of the greatest importance.

Advantage of scientific agriculture.

PLANTING.—The cuttings are planted in furrows made by the plough, or in holes dug with the hoe in places where ploughs cannot be used, or where, for some reason or other, their use is rejected. In the latter instance, it is well to pick-axe the holes before the cuttings are planted, so as to loosen the soil for the free entry of the delicate rootlets. The holes are from eight to twelve inches deep, and their size depends on the distances at which the plants are set, and this in its turn depends on the nature of the soil and climate. Formerly the canes used to be planted much closer than is customary now. Three feet between the rows and two feet apart were common distances, but now in good lands the rows are often seen seven feet apart and the plants six feet from each other in the rows. The average distance in the West Indian Islands, however, is 5 feet by 5 feet. On hill sides, and in poor soils, their distances may be decreased, and in places where the canes are planted in furrows made by a double mouldboard plough, it is customary to place the cuttings much nearer to each other.

Preparing the land.

Caneholes.

Distances.

Planting on hill sides.

Two cuttings, or plants, are placed in each hole in a slanting direction. They are usually about six inches long; and, as about an inch is left out of the ground, five inches are buried in the soil. In favourable weather they will send up

Putting in the plants.

sprouts above the ground and become rooted in from ten to fourteen days. These sprouts or shoots become the *mother-plant*, and they send up other shoots in time. The mother-plant should be cut out as soon as it begins to joint; for, in this way, all the strength will be sent into the surrounding shoots and cause them soon to develop into canes. When, owing to dry weather, or to other causes, some of the cuttings do not take root, it is necessary *to supply* the vacant holes, and, in order that the supplies may not produce canes backward in growth, as compared with the rest of the cultivation, growing plants are dug from the roots or *stoles* of canes thrown out of cultivation. An infinitely better plan would be to establish nurseries of plants raised from selected cuttings; for, in this way, the returns from the supplies would be greatly increased, as the weight of canes obtained from each hole governs the quantity of sugar made. A Barbados planter has calculated that "a bunch of canes grown in one hole weighs 54lbs. on an average, which yields 4 gallons of juice, from which 4lbs. of muscovado sugar are got." At this rate over three tons of sugar would be got from an acre of cane land, but on many estates in the West Indies, owing to bad cultivation and other causes, barely half this quantity is obtained.

Cut out the mother plant.

Supplies.

Nurseries of plants.

Return from a single plant.

CULTIVATION.—Tillage is one of the most important operations in cane cultivation, for the better the tilth the greater the returns. Before planting, the land should be well hoed and ploughed, and the weeds ought to be buried so as to form a green crop manure. Except in heavy clay land it is a bad system to burn the weeds and rubbish, for the fire dissipates the nitrogenous substances, and thus prevents their retention in the soil as plant food. If the land be ploughed a subsoil plough should be run in the furrows where practicable, as the turning up of the deeper layers of the land greatly increases the soluble constituents available for assimilation by the roots of the cane.

The better the tilth the greater the returns.

Subsoil ploughing.

After planting, the fields must be kept clear of weeds

until the canes grow up and shade the soil, when the weeds will no longer give trouble. In some of the West Indian Islands, such as Barbados for instance, the "farm" or "garden" system of weeding has been adopted with great success. A portion of the cane field is given out to labourers who receive regular pay for keeping the land absolutely free from weeds. In places where this system has been established, it is found that the weeds do not after a time give very much trouble, for their constant eradication prevents seeding and tends to kill them out. Some planters plough lightly between the rows after the canes have made some little growth, and this acts beneficially by loosening the soil, and by exposing some of its under surfaces to the fertilising action of air and sunlight.

Frequent weedings required.

The garden system.

Light ploughing between the rows beneficial.

From October to January is generally considered the best time for planting canes in the West Indies, but no general rule can be laid down, as climate and local circumstances must be taken into account. In October, the canes throw out flowering stems, called *arrows*, and these are long terminal shoots bearing pyramidal tufts of mauve-coloured, downy blossoms. The flowers are sometimes collected and used in the stead of feathers for pillows.

Planting seasons.

Arrowing.

As the cane grows, the lower leaves wither and dry up and usually remain attached to the stem. In dry weather, the dead leaves, called *trash*, must be left alone, but on rich soil and in wet weather they will interfere so much with the circulation of air amongst the vegetation and in the ripening of the canes that it becomes the duty of the planter to have them separated from the canes and strewn on the ground over the roots. This is termed *trashing*, and by leaving the trash at the roots of the canes it will rot and form excellent manure.

Trashing not necessary in dry weather.

At the time of "arrowing" or flowering, the canes are poor and weak, the juice being watery and deficient in sugar. But the flowers do not form seed—save in exceptional cases, and the plants soon recover from the exertions they have put forth in flowering. Canes are usually ripe and fit for

The maturation of the canes.

WORKING BETWEEN THE ROWS OF CANE WITH A "DAUNTLESS" CULTIVATOR.

CANE FIELD AFTER CULTIVATION.

[*By courtesy of Messrs. Ransomes, Sims & Jefferies, Ltd.*

SUGAR CANE FIELD: CUTTING THE CANES, JAMAICA.

[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

Plant canes and rattoons.

cutting in about twelve to fourteen months from the time of planting. This applies only to tropical countries. The cultivation of canes from plants has hitherto been considered, but on some sugar estates only a portion of the land is occupied by these *plant canes* as they are called, the other part being cultivated in *rattoons*, which are simply canes grown from the *stoles* or roots left in the ground after the plant canes are cut. Rattoons are called first, second, third and so on, according to the number of crops taken from them. On very rich soil, the rattoons have been known to produce crops for twenty years, the canes having been cut annually, and the stoles allowed to throw up shoots again. But this continuous cropping of the same soil exhausts the land, and causes the canes to deteriorate so much in size and quantity as to give unremunerative returns. It rarely happens, therefore, that rattoons are cultivated beyond the third or fourth, or at most the fifth year, the land being then allowed to fallow so as to prepare it later on for plant canes.

Different kinds of rattoons.

Fallowing.

When the canes are cut.

Crops.—The crop-time in the West India Islands is usually from January to May, but the cutting operations must not be commenced till the canes are ripe. "The maturity of the cane is indicated by the skin becoming dry, smooth and brittle; by the cane becoming heavy; the pith grey, approaching to brown; and the juice sweet and glutinous." On cutting a ripe cane across, the inner tissue is dry, and it contains white particles; in an unripe cane, on the other hand, the interior is soft and moist from the presence of unelaborated sap, and in this condition it is unfit for cutting. If an unripe cane be bent it will break off at the joint or node, as if cleanly cut with a knife. A ripe cane, on the other hand, will not break off in this manner as the tissues are more fibrous. The mature cane varies much in length and breadth according to differences of soil and climate, and also according to the variety of the plant.

Mature canes.

How distinguished.

Unripe canes.

There are many different varieties cultivated in the West Indies, but the Otaheite or Bourbon is the kind most often planted. In the rich and most alluvial lands in British Guiana, the canes sometimes attain the length of 20 or even 25 feet, but from 10 to 12 feet are the lengths most often met with, and in a good deal of the cultivation in the West Indian Islands they are not even as long as 10 feet.

Varieties (see also p. 196).

Average length.

The canes are cut right down to the ground as near to the stole as possible, for the root end is always richer in sugar than any other part, and the close cutting increases the vigour of the rattoons. For the convenience of handling, the canes are sometimes chopped into lengths of four or five feet and tied up in bundles. These are then carted to the works to be *ground* in the mill, by which process the juice is pressed out of them.

How the canes are cut.

Grinding the canes.

Plant canes yield a larger return of juice, and therefore of sugar, than rattoons; but the juice from the latter is richer in saccharine matter and it gives a finer quality of sugar. Besides, there is much less trouble and expenditure in cultivating the rattoons, and the sugar is manufactured from them with less difficulty. It follows, therefore, that the cultivation of rattoons is more profitable than that of plant canes, but as the former deteriorate year by year it is necessary to renew the plants at stated intervals.

The cane juice.

Rattoons more profitable than plant canes.

In British Guiana [1] it has been found that good cane cultivation gives about 30 tons of canes to the acre, and this will yield about 25 tons of juice containing from 15 to 18 per cent. of crystallisable sugar. But only six or seven per cent. of this sugar is extracted by the best manufacturing processes, and thus the return is only two hhds. or 36 cwt. to the acre. These figures may be taken as fair average ones for cane culture, but in certain instances the returns are larger or smaller according to the peculiarities of soil, climate or cultivation.

Returns from an acre of canes (see p. 198).

[1] A seedling cane—D. 625 (see p. 197) is now (1928) the chief cane grown.

MANURING.—On most of the sugar estates in the West Indies the canes have been planted on the same soil for very many years, and thus if the planters had not manured their lands, the soil would have become barren long ago, for the cane is a very exhausting crop, as it extracts large quantities of inorganic matter from the land. Sugar itself is composed of three organic elements, viz.: carbon, oxygen and hydrogen, all of which are obtained from the atmosphere and water alone. But, in order to build up the sugar in its tissues, the organs of the plant require quantities of inorganic materials which must come from the soil. Careful analysis has shown that ripe sugar cane (Otaheite) contains 0·48 per cent. of ash, which is about one part in nearly every two hundred. A crop of 30 tons to the acre would remove, therefore, nearly three hundredweights of the inorganic constituents of the soil which exist in a soluble form; and, as the cane refuse or *megass* is used for fuel, and the tops are used as fodder for cattle, nearly the whole of this inorganic matter is taken away from the soil absolutely. The following table is calculated from an analysis of the ash of a ripe cane and its leaves by Dr. Phipson, and it shows at glance what constituents are removed from the soil by the canes, and what special kind of manure may be necessary :—

Sugar cane an exhausting crop.

Composition of sugar.

The quantity of ash of the cane.

Drain on the soil.

Analysis of the sugar cane.

	Per cent.
Potash	18·00
Soda	2.00
Lime	10.00
Magnesia	6.50
Sulphuric Acid	8.00
Phosphoric Acid	6.00
Chlorine	4.50
Silica	43.00
Oxide of iron, manganese, &c.	2.00

Duggar, *seq.*, quotes: "In Louisiana where the tops and leaves are burned on the land, the loss of plant food represented by a crop of 25 tons to the acre of stripped cane

(Purple) is found to be nitrogen 70 lbs., phosphoric acid 26 lbs. and potash 30 lbs."

When farm yard manures are obtainable, they will supply all the necessary constituents for the cane, but it is rarely that sufficient are available, and it is necessary for the sugar planter to make up for the drain on the land by the application of special manures, such as guano, gypsum, &c. In all cases of cane cultivation on a large scale, it is advisable that the planter should have samples of his soil, both surface and sub-soil, analysed in order that he may know what of the constituents of the ash of the cane are absent or deficient in quantity and what proportion are in a condition to be available for plant food. He can then supply the deficiency by using a manure, rich in the constituents wanting in his soil. But to apply manures haphazard, is to run the risk of throwing away money in purchasing what the soil does not require ; and, therefore, what is utterly useless.

Special manures.

Analysis of the soil advisable.

Select the right manures.

MANUFACTURE OF SUGAR.—Two principal kinds of sugar are now made in the West Indies, namely, raw or muscovado and crystals. The muscovado sugar is shipped to Europe and North America, and there it is, for the most part, converted into loaf sugar in the various refineries. The crystals go to the consumer without any further preparation ; and as they are made only on large estates by complicated machinery, it would be out of place to give a sketch of the process in this book. Muscovado, or raw sugar, is prepared on the smaller properties ; and, in those colonies where the sugar industry has not attained to very large proportions, it is the only kind made. The various stages in the manufacture are well known to most persons in the West Indies, and it is only necessary to allude to it briefly here.

Two kinds of sugar.

"Crystals."

Muscovado

The ripe canes are brought to the mill in such quantities that the manufacture can keep pace with the cutting, for the juice is exceedingly fermentable, and it must therefore have heat applied to it for the purpose of clarification as soon as it leaves the mill. Various kinds of mills are used, some with the rollers placed vertically and others with them

The cane juice ferments easily.

Mills.

How the mills act.

arranged horizontally. In all the mills the canes receive two compressions to force out the juice, and the fibrous material

Megass.

left by the canes after the juice is extracted is called *megass*, and it is used as fuel for the furnaces under the boiler and clarifiers.

The impurities of the juice.

The cane-juice as expressed by the mill contains in suspension various matters such as particles of woody tissue and cellular substances, &c. In order to remove these impurities the juice is run into vessels or pans called *clarifiers*, and a little unslaked lime is added so as to neutralise the vegetable acids. The clarifier is then heated and the impu-

Scum.

rities rise as scum, which is removed and the juice is said to be *defecated*. The hot juice is now run into the first of a series of cast iron or copper open pans or boilers where it is subjected to great heat. As the juice boils, the scum which

Skimming.

rises is skimmed off; and, in consequence of the evaporation of the water of the juice, the bulk is decreased and the liquor becomes thicker. It is then ladled out into the next boiler,

Charging the boilers.

which is smaller than the first one, and more juice is run into the large boiler from the clarifier. As the liquor becomes denser it is transferred from boiler to boiler, which usually decrease in size, until it enters the last and smallest one which is called the *teache*, and which is usually the fourth boiler. The liquor, which has now become a concentrated syrup, is boiled in the teache until it is in a fit state to granulate into

Striking from the teache.

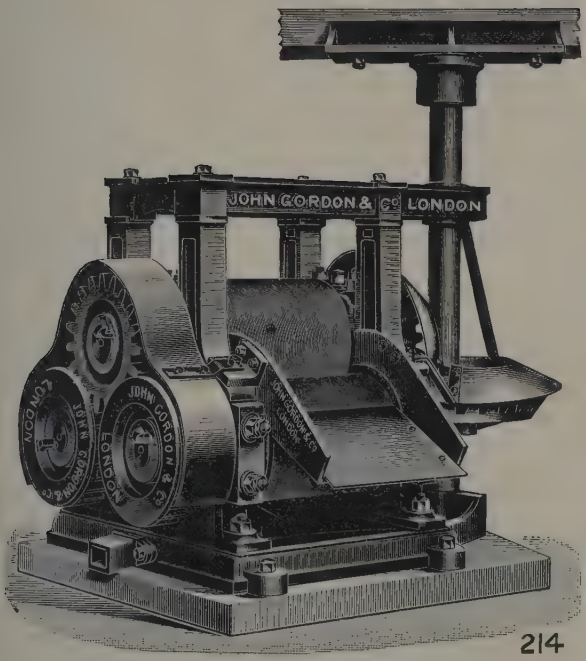
sugar, when it is transferred to flat open wooden coolers, and this is termed *striking*. The sugar granulates in the coolers,

Granulation of the sugar.

but it is mixed with much uncrystallisable saccharine matter called *molasses*. After remaining a sufficient time in the cooler the sugar is *potted*; that is, it is dug out and packed in hogsheads with holes at the bottom for the molasses to

Draining of the molasses.

drain off. In order to assist the drainage the stalks of the plantain leaves—which are long enough to reach the top of the hogshead—are put through the holes in the bottom, and they are withdrawn as soon as the molasses are drained off.



THREE-ROLLER SUGAR CANE CRUSHING MILL, WORKED BY ANIMAL POWER.

This illustration shows a mill for crushing sugar cane and worked by animal power. The mill is fitted with three horizontal rollers between which the sugar canes are passed: the canes are delivered to the back, while the juice drops into a basin formed in the baseplate, and is delivered at one end through a spout, where it can be led away to the boiling pans.

Cleanliness essential.

In all the operations for the manufacture of sugar, cleanliness should be observed. After grinding, the mill should be properly cleaned, and the parts of the iron that the

Cleaning the mill.

juice has been in contact with ought to be brushed over with lime so as to neutralise the vegetable acids, which would otherwise do much harm to the juice at the next grinding.

Recent progress.

The above notes, referring, as they do, more particularly to the West Indies and British Guiana of thirty years or so ago, may in general apply in no small degree to the present time; but considerable allowance must be made for improvements in varieties of cane grown, methods of sugar manufacture and economic conditions in general.

"Bourbon" cane.

The "Bourbon" cane, also known as "Otaheite," "Lahaina" (in Hawaii), "Creole" (in Peru), appears to be still commonly grown in the Islands; though in general it has not been found successful under all conditions, and it seems to have shared the fate of most varieties in giving signs of deterioration after long and continuous cultivation in certain localities. Peru is an exception, this cane being almost exclusively grown there.[1] It is, however, a famous cane and has had a long run—a French navigator (Bougainville) brought it from Otaheite to Bourbon about 1766, from whence it was transferred to the French West Indies, and Capt. Bligh introduced it into Jamaica from Otaheite with the bread-fruit in 1791[2]—and it usually thrives and retains its vigour when grown in virgin soil or

"White Transparent" cane.

given good cultivation. "White Transparent" and "Red Ribbon" canes are other old varieties that seem to have stood the test of time; but even "White Transparent" has in some instances been replaced with decided advantage by "seedling" canes, notably in Barbados.[3] The opinion has been advanced that the economic life of cultivated varieties is longest where reproduction by seed is rarely if ever

[1] Int. Sugar Journ., Nov. 1926, p. 593.
[2] *Ibid.*, Dec. 1926, p. 650.
[3] Proc. West Indian Agric. Conference, Jamaica, 1924, p. 96.

ossible, and so we find vegetative propagation, as already tated, the only means the planter finds possible. The aising of new varieties—selected by chemical analysis, veight of stems, &c., in comparison with standard canes— rom seed, however, is an important part of sugar-cane ultivation that has been followed up with infinite care y various Government Departments of Agriculture and Scientific Institutions. So far they have been successful in roducing varieties, recognisable by a number with the initial etters of the place of origin, as D. 625 (Demerara), B. 208 Barbados), B.H. 10 (12) (Barbados Hybrid), J. 72 (Jamaica), P.O.J. 2878 (Proefstation Oost Java), &c., that have been ound to give very satisfactory yields.

Raising of new varieties from seed.

It is quite impossible to do this subject justice here, and reference should be made to the writings of workers in the ield—Bovell (Barbados), Harrison (B. Guiana), Watts W. Indies), Cousins (Jamaica), Barber (India), Stockdale Mauritius), &c. Nearly every country has its own successful variety; in Cuba "Crystalina"[1] is an established variety most generally grown; "Cheribon"[1] (purple) and new seedling canes in Java—where the seedling cane P.O.J. 2878 above mentioned is a striking instance of development. Raised in 1921 (parents P.O.J. 2364 × E.K. 28), in 1922 there was one full-grown plant; in 1925 there were 1,750 bouws (1 bouw = 1·75 acres), and in 1926 about 25,000 bouws under cultivation. The advantages claimed over standard varieties are that it flowers very little, has high sugar content, great weight of cane, and is very slightly affected by "mosaic."[2] "Rose Bamboo"[1] is recommended in Hawaii, where it has replaced on an extensive scale the "Lahaina" cane ("Bourbon" or "Otaheite"); "Uba" in Natal, Madeira, Portuguese East Africa, and also to some extent in Jamaica, where, with the exception of "Uba" and B.H. 10 (12), no

Varieties grown in certain countries.

[1] Deerr, *seq.*, includes these varieties under Batavian, Java or Cheribon canes.

[2] Int. Sugar Journ., Jan. 1927, p. 26; Feb. 1927, p. 68.

other cane by actual field tests has been found to suit the estate conditions like the variety "White Transparent"[1]; whilst the "Tanna" variety is reported to be grown on an increasing scale in Bengal.[2]

Yield.

The figures given on p. 191 as to yield of sugar from a stated amount of cane works out at approximately 1 ton from 16½ tons of cane, thus agreeing with a statement made at the Agricultural Conference in Jamaica, 1924,[3] to the effect that twenty years before it required 16½ tons of cane to make 1 ton of sugar, but now the same amount of sugar can be obtained from 8½ tons of cane. Some further yields of cane per acre are advisable here, and the figures obtained by Bovell in Barbados are given.[4] "On the average for eight years 'White Transparent' yielded 20·45 tons of cane per acre; the B.H. 10 (12), 29·05 tons; Ba. 6032, 31·76 tons of canes per acre, per annum, respectively. An ordinary three-roller mill extracts on the average about 60 lbs. of juice from every 100 lbs. of canes."[5]

Central factory.

The central factory (see p. 182) has increased in usefulness and is indispensable to small proprietors. It is only very large estates that can afford the expensive equipment essential to the manufacture of sugar on modern lines. The pioneer factory was in Antigua, initiated by Sir Francis Watts. The St. Kitts (Basseterre) Sugar Factory, Ltd., erected a factory some years ago, the original cost of which was £157,520, including forty miles of railway; since extended, making a total cost of £281,746, the factory now deals with the whole of the canes grown in the island under a system satisfactory both to the planters or proprietors on

[1] Proc. West Indian Agric. Conference, Jamaica, 1924, p. 147. Deerr, *seq.*, includes "White Transparent" with the varieties mentioned on p. 197, under Batavian, Java or Cheribon canes.
[2] West Indian Comm. Circ., Jan. 4, 1926, p. 10.
[3] Proc. West Indian Agric. Conference, Jamaica, 1924, p. 140.
[4] *Ibid.*, p. 142.
[5] *Ibid.*, p. 143.

he land and the manufacturers or proprietors in the factory.

The prices in Dec. 1926 on the London market were for the "Muscovado" 23*s.* 9*d.* per cwt., duty paid, and for the "Crystallised" West Indian, 31*s.* 3*d.* per cwt., duty paid (see p. 193). Though the chief producers of sugar are Cuba, Java and British India, where in each of these countries the annual production exceeds 1,000,000 tons, it is also grown on a commercial scale in Egypt, Natal, Mozambique, Mauritius, Formosa, Philippine Islands, Queensland, Brazil, the Guianas, Venezuela, Peru, Central America, Louisiana, Porto Rico and Hawaii; the imports to the United Kingdom from all sources totalling more than 800,000,000 lbs. per annum, value (at approximately 10*s.* per cwt.) £3,571,430. Market prices. Production.

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CHAPTER VI

FRUITS

The Orange. *Citrus Aurantium*

In commercial importance for its fruits, the orange family is said to come next to the vine, but the greater part of the grapes cultivated are made into some form of wine or spirits, and so, taken simply as a fruit, the orange and its allied species may be said really to be the most important of all the fruits cultivated by man. The orange can be raised in quantities only in tropical and sub-tropical climes ; and, as the consumption of the fruit is greatest in temperate zones, a very large trade is done in its cultivation and sale. Until within comparatively recent times, nearly all the oranges sold in the great fruit markets of Europe and North America, were raised in the islands of the Atlantic lying off the Northern coast of Africa, and in the countries bordering on the Mediterranean Sea. But the increase of steam communication with the West Indies has caused the fruit trade of some of the West Indian Islands to become greatly augmented, and a trade in oranges has been established between the United States and Jamaica, the Bahamas and Dominica. By careful packing and selection the fruit can be kept so as to undergo long sea voyages : and, as the orange trees grow in the West Indies perhaps more luxuriantly than in any other part of the world, there is no reason why the bulk of the oranges consumed in the United States should not be

Importance of the orange family.

The orange trade.

The West Indian trade.

The Florida trade.

grown in these colonies. There is very little fear of over production; the only serious competition would come from Florida, but sometimes an occasional ice wave passes over that country and kills back the orange orchards, so that several years must elapse before the trees recover from the death of their principal branches.

ORANGE. *Citrus Aurantium.*

Production.

The Canary Islands are an important field of production, and in South Africa the trade in oranges and other Citrus fruits is of growing importance; from small beginnings in 1907 the productive area is now estimated to cover 25,000 acres. Spain is our most important source, upwards of 500,000,000 lbs. being imported into England yearly, when (1913) the imports from all sources—Spain and other

Mediterranean countries, United States, S. Africa, and British West Indies, stood approximately at 600,000,000 lbs. of oranges. In 1924 the total home imports were over 800,000,000 lbs., or to the value of about £7,000,000. When the fruit can also be sold to local buyers, there is perhaps no more profitable fruit under cultivation than the orange. The cultivation a profitable one.

SOIL.—The orange tree will grow in almost any soil except a sandy one, provided there be good drainage and a sufficient depth for the long tap root to descend. Good crops, however, can be expected only from rich land, for all the members of the orange family love a "generous soil." Clays, loams, marls and calcareous soils are all suitable, and the larger the amount of humus the better will the tree thrive. Rich soils the best.

CLIMATE.—The orange tree is perhaps the hardiest of the members of the *citrus* family, it luxuriates in the tropics, it grows well in the sub-tropics, and it will endure the mild frosts of the south of France. But in these latter climates, the fruit is much less abundant than it is in the tropics ; and, judging by the luxuriance of growth of the oranges of the West Indies, one may say that the climate, in favoured localities in these colonies, is the typical one for the orange-tree. Elevation up to 2,000 feet does not appear to have much effect on the crops. But the trees are raised more easily, and the fruit is larger and more luscious in warm, moist localities in the mountains. Shade is quite unnecessary, for the tree delights in the sun, and overhanging shade causes the stems to run up like whips. The roots take so firm a hold on the ground that the tree bears a good deal of exposure, but in very windy places, the crops are short by reason of the flowers and young fruit being blown off. Shelter belts of trees are therefore advisable in such places, but they must be used as "break-wind fences" and not as overhanging shade. Tropical climates best. Elevation. Shade unnecessary. Shelter.

CITRUS SEED-BED UNDER LATH.
[*From "Citrus Fruits," by Dr. J. E. Coit*

PROPAGATION. — Orange-trees are often raised from seed, and no better oranges can be grown than those produced from some seedling trees. In Florida and other parts of the Southern United States, the oranges are mainly propagated by budding sour stocks, for the sour orange has become wild in some parts of those countries. The "rough lemon," also, is commonly used as a stock. In Europe the best oranges are grafted, and grafting or budding is necessary to preserve the characteristics of the fruit. Seedling trees at one time were common and produced fruit of good quality ; they may still be grown in parts, but for commercial purposes the advantages of asexual methods of propagating, chiefly by budding, are generally recognised for all the good varieties—"Washington Navel," "Valencia," "Jaffa," "Maltese Blood," "St. Michael," &c.

Seedlings.

Budding sour stocks.

Grafted oranges.

The seed may breed true, but asexual methods are the best.

The seeds should be planted in nurseries prepared in the manner described in former chapters ; or, if the cultivation is not to be carried out on a large scale, it is perhaps better to sow them in boxes raised off the ground, as rats and mice are particularly fond of them. The seeds must be planted fresh from the fruit, for they lose their germinating power on drying, and they cannot be carried long distances unless they be preserved in earth, for, strange as it may appear, seeds kept in earth will remain fresh much longer than those left in a dry place above the soil. One orange seed often contains several embryos (see p. 208) and this is why it happens that when the seeds are planted at distances several seedlings are found afterwards growing close together. The seeds must be sown three or four inches apart, and there should be from six to nine inches between the rows. Seedlings intended for stocks should be transplanted when 6 to 12 months old from the nursery beds to about 3 ft. apart in rows 4 feet apart. The time may vary, but the young plants may be budded from 12 to 18 months later and ready for putting out in the field when the bud growth is well established, or in the course of another year.

Nurseries.

Fresh seed necessary.

Several embryos in one seed.

Distances in the nurseries.

CITRUS SEED-BED IN THE OPEN IRRIGATED BY SPRINKLING.
[*From "Cultivation of Citrus Fruits," by H. H. Hume.*

FOUR-YEAR-OLD VALENCIA ORANGE GROVE.
[*From "Citrus Fruits," by Dr. J. E. Coit.*

CITRUS TREES IN NURSERY ROWS.

[*From "Cultivation of Citrus Fruits," by H. H. Hume.*

Distances in the fields.

PLANTING.—The distances at which the trees are planted depend principally on the nature of the soil. In rich forest land with a deep and porous soil, 25 feet each way will not be too far, but in drier places and on poorer soil 20 feet is the proper distance. At 25 feet there would be 70 trees to the acre, and at 20 feet there would be 108.

Holing the land.

Except in very favourable places, where a rich, deep and friable soil is found, holes must be prepared for the plants, which should be put in at the commencement of the rainy season. In removing the plants from the nurseries, if the tap root be broken it should be pruned with a sharp knife;

Pruning the tap root.

AN ORANGE SEED, WITH SEVERAL EMBRYOS.

as it is a bad system to put in the young tree with a jagge wound of the main root. With proper care there will be ver few "misses," for the orange is very hardy and eve moderately large trees can be successfully transplanted in th wet season.

Importance of good cultivation.

CULTIVATION.—When an orange grove is formed, th returns will depend greatly on the cultivation. The tree will grow and give crops without anything whatever bein done to them, but such trees will improve wonderfully if the be properly attended to. The ground should be kept weede and well stirred up. As the tree throws out many superficia

oots the soil in the immediate vicinity of the stem must not be stirred deeper than a few inches, except at intervals of a ear or so when careful pickaxing will do good. Between he rows the deeper the tillage the better. On level land the lough may be run so as to form several furrows in the entre of the lines, and it will prove advantageous if the sub-oil be turned up at the same time.

Deep tillage between the rows.

On many properties it is not always practicable to form a egular "orange groove"—which is the term applied to the lantation; but a great number of trees may be grown along oads, and in odd corners of the property. The tree, as was ointed out, is a very firm rooter, and after a hurricane it is ecorded that orange trees have been found standing erect, nd almost unhurt, whilst other trees in the neighbourhood were blown down or even torn up by the roots. The stable nature of the trees may, therefore, be taken advantage of by planting several rows of them wide apart through coffee, cacao and other plantations, for in the event of hurricanes these belts will serve as sure protection.

The trees are firmly rooted in the ground, and thus withstand hurricanes.

MANURING.—No other tree, perhaps, responds so readily to judicious manuring as the orange. On poor soil with a deficiency of vegetable matter, the tree will look sickly, its leaves will be yellowish, and its crops small; but the free application of a nitrogenous manure will soon cause a wonderful alteration in the vigour of the tree, and the number of the fruit borne. When the young trees are well rooted and growing, the application of farm-yard or green crop manure will push them on very much; and when the trees are bearing they should be manured every year. Guano and wood ashes are sometimes used with success, and liquid manure poured over the roots is most beneficial. Indeed, the soil should be made as rich as possible, for the richer the soil the greater the return, provided the physical conditions also are good.

Nitrogenous manures most beneficial.

The trees to be manured every year.

CATCH CROPS may be grown between the trees with advantage, for as the distances of planting are wide, and as the

Catch crops to be recommended.

trees take from five to seven years to come into bearing, the land would be kept idle for too long a time if intercropping

Catch crops. were not resorted to. Water melons (*Citrullus vulgaris*) white Madagascar, Burma, or butter beans (*Phaseolus luna tus*), pine-apple (*Ananas sativus*) or any fruit, vegetable o pulse that comes to maturity quickly might be grown with advantage. The soil at the same time would be kept in good tilth.

Necessity of pruning. PRUNING.—The trees require pruning from the first After the plants are put out and vigorous growth takes place a lot of stems sometimes spring up around the central one These must be carefully pruned off, and the young tree must be trained to send up a clean, straight stem branching about

How to prune the trees. five feet above the ground. As the tree grows up, the latera branches close to the ground must be removed with a clean cut close to the stem, so as to enable the bark to grow over the wound. But too many of these branches must not be taken away at a time, as heavy pruning retards the general growth greatly. When the trees are mature, dead and ill-shaped branches should be removed with the pruning saw the wound being trimmed with a knife, and tar being painted over it to prevent decay entering into the heart of the tree.

CROPS.—In the West Indies the crops are usually in from September to February, some trees bearing earlier and some

Advantages of early crops. later. The earlier the produce gets to the market, the greater are the prices obtained, as the Mediterranean oranges are not in full season until the beginning of the year, and so every attempt should be made by the planter to induce

How to get early crops. his fruit trees to bear early crops. A good deal in this direction can be done by irrigation, careful pruning, and by keeping back the fruiting period, and when a very early bearing orange tree is obtained it should be propagated by budding and grafting.

The yield of oranges from individual trees. The yield of oranges varies very much—soil, climate and cultivation being important factors in determining the extent of the crops. In California from 400 to 600 oranges are

borne annually by the trees. In the Azores and in Florida these figures have been exceeded, and in the West Indies from 3,000 to 8,000 oranges are recorded from single trees. But overbearing is not advisable and judicious thinning of fruits in the early stages is recommended. A good average would appear to be 350 to 500 oranges per tree annually. Yield of oranges.

In gathering the oranges, particular care must be taken not to bruise the fruit, as one bruised orange will often cause all the other oranges packed in the same box to become rotten. Ladders must be used for tall trees and the stalks must be cut, for to tear the fruit off the trees is to run the risk of serious loss. Oranges gathered with a portion (about a quarter of an inch) of the stem attached are called "stem-cut" oranges and they keep better than others. Gathering the oranges.

ENEMIES TO THE ORANGE TREE.—The orange, like most other cultivated plants, has its enemies, but, fortunately, in the West Indies, these are neither numerous nor formidable. The most important is the scale insect or *coccus*, which if left to itself may kill out the young trees and prevent the fruitfulness of the matured ones. It may, however, be got rid of by brushing the stem and branches with a solution of whale-oil soap in water, to which a small quantity of kerosine oil has been added. A decoction of tobacco, beaten up with carbolic soap so as to form suds, is also a valuable insecticide if it be brushed over the bark of the trees and allowed to dry on. And to paint or syringe the trees with wood ashes and water, or with white-wash made into a thin fluid, very frequently destroys blights both animal and vegetable. The *rust* on the oranges is caused by an insect blight which may be killed out by dusting quick-lime over the trees, it being usually sufficient to stand under the tree and to throw up the lime in handfuls when the leaves are moistened by dew or by light showers, but particular care must be taken that none of the lime gets into the eyes of the operator. The scale blight. Insecticides. Rust.

PACKING FOR THE MARKETS.—It has been shown that extreme care should be taken in gathering the fruit, and the same care is necessary in packing. The oranges intended for export must be gathered before they are ripe, but they ought to be fully formed. It is not necessary that they should be yellow, for they will ripen after they are gathered, and in the ripening process the green skin turns yellow. A dry day should be selected on which to gather the fruit; as, before packing, all the moisture about the skin must be evaporated. The best plan is to set the oranges on shelves for a day or so, in the packing shed, and, when they are dry, any bruise or defect is easily seen.

Unripe oranges to be gathered for export.

Oranges to be packed dry.

Packages.

Oranges are shipped from the West Indies in empty flour barrels, and in boxes. The barrels usually have holes cut in the staves for the purpose of ventilation, and each barrel will contain about 300 oranges. But a much safer plan is to ship in boxes, the usual size being 2 feet and a half long by one foot in depth and one foot in width. The ends of the boxes are solid, but the top, bottom and sides are boarded up with laths 3 inches wide, a space of about 2 inches being left between the laths. The box is divided into two equal compartments by a solid piece of wood, similar to the pieces used for the ends. Each of the boxes will contain about 150 wrapped oranges of the larger kinds or 180 of the smaller fruits. In Florida the box as illustrated—inside, 12 by 12 by 24 inches, commonly made of yellow pine—is the standard package for oranges, and contains, according to size, 96 fruits ($3\frac{1}{2}$ inches diam.) in 4 layers to 250 fruits ($2\frac{1}{2}$ inches diam.) in 6 layers. The centre bulge in the top must not exceed $1\frac{1}{2}$ inches. Each orange must be wrapped in paper, care being taken to reject all inferior or damaged fruit. The paper used is recommended to be light but strong and stamped with name and address of the grower. The packing should be so close that the oranges will not shake about, indeed in nailing up the laths on top it is as well that they should slightly compress the fruit, as it dries and decreases in bulk on the

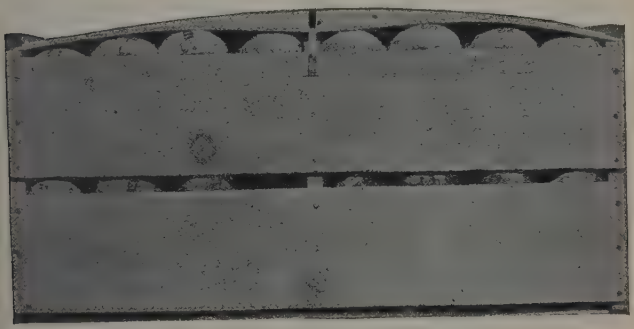
Boxes.

Number of oranges in a box.

Wrapping the oranges.

voyage. The oranges in each box should be of the same size and of the same degree of ripeness. These are matters of great importance. Before packing the fruit ought to be sorted out, each kind being packed separately, for when a buyer takes a sample orange out of a box he expects to find all the fruit of the same size and quality as the sample. After

The oranges to be sorted.



WELL-PACKED BOX OF ORANGES, SHOWING AMOUNT OF BULGE.
[*From "Cultivation of Citrus Fruits," by H. H. Hume.*

the boxes are packed they should be handled carefully, for fear of bruising the fruit; and, if the estate be far from the shipping place, it is as well for the packages to be carried in light spring waggons as in Jamaica, lest the jolting of a cart should injure the delicate contents.

Careful handling necessary.

THE LIME.—*Citrus Medica var. acida.*

IN regard to commercial importance, the lime comes next to the orange. The acidity of the fruit is more pronounced than that of the lemon, and many persons prefer it on that

WEST INDIAN LIME (*Citrus medica*, var. *acida*).

1, Flowering branch (slightly reduced). 2, Transverse section of fruit (reduced). 3, Portion of fruit rind (enlarged, showing oil glands).

[*From Botanical Magazine, tab.* 6745.

account. Limes are shipped in small quantities to Europe and North America packed in the same way as oranges; but, as the lemon is a better known fruit, it will take some time before there is a demand for limes in the great fruit markets. Lemons.

Limes are now, however, principally grown for the sake of their juice, which is shipped from Montserrat and Dominica in a concentrated form, and from these two islands—as well as from Jamaica and Trinidad—it is sent to Europe and the United States, in its natural or "raw" state. The concentrated juice is the source of a considerable portion of the citric acid used in medicine and the arts, and the natural fruit juice is bottled up and sold in Europe and America as a refreshing and wholesome beverage. It is also used as an antiscorbutic,—that is, to prevent the outbreak of scurvy on board ships and elsewhere—and all English vessels leaving Great Britain for long voyages are bound to have a good supply of lime juice on board. The spread of temperate habits in many parts of the world is calculated to increase the demand for the juice of the lime, for it makes a most grateful and perfectly innocuous drink at all times. The trade in lime juice—raw and concentrated—from the countries mentioned, though still of some importance, has unfortunately fallen off to some extent, due to "wither-tip" and "blossom-blight," a fungoid disease (*Gloeosporium*), attacking the tender tissues of the trees. Concentrated lime juice. Citric acid. Raw juice. Trade affected by "wither-tip" and "blossom-blight."

SOIL.—Those soils suitable for the orange are the best for the lime, and the richer they are in nitrogenous constituents and potash the larger will the crops become. The lime, however, is hardier than the orange, and although it has a tap root, the main supply of food from the soil is taken up by the lateral roots which spread for long distances close to the surface of the ground. It follows, therefore, that the lime will grow in shallower soil than the orange, but in such situations it grows slowly and it bears small crops. The lime a hardy plant.

The best climate.

CLIMATE.—The best climate for the lime is a hot, mois one, such as is found in sheltered valleys from 300 to 50 feet above the sea in the well-wooded West Indian Colonies The tree will bear a certain amount of exposure, but hig winds knock off the flowers and young fruit, and thus ver

Shelter belts.

seriously diminish the crops. Shelter belts of trees should therefore, be grown when the lime is planted in exposed situations.

Seedlings.

PROPAGATION.—This takes place by seeds which are very abundant in the fruit. The seeds are planted in the same way as those of the orange, but as they are so plentiful they may be sown broad-cast in the nurseries and afterwards raked into the soil. Soon after germination has occurred the weakly seedlings can be weeded out, and the whole nursery may be thinned with advantage.

Planting at stake.

PLANTING.—This also is done in the same way as is adopted in the case of the orange, but some planters sow a few seeds in the field when the trees are to remain. When the seedlings are 18 inches high, all but the one to be left are to be weeded out, or they may be dug up carefully so as to be used for supplies, or for increasing the planted area.

Distances.

The distances at which the lime trees are usually planted vary from 10 to 20 feet, and this gives an average of 15 fee between each plant and between the rows, but the same dis tances cannot be adopted for the planting of all lands. On steep hill sides 10 feet will not be too close, and on rich bottom lands, at 20 feet distance from each other, the trees in ten or twelve years will meet and completely shade the ground

CULTIVATION.—This is the same as for cacao or oranges and with careful weeding and an occasional stirring of the soil, the trees will commence to bear in three years from the

time of planting. Some planters do not weed, but allow pasture grass to grow between the trees for the purpose of raising cattle; but this plan cannot be recommended, except on steep hill sides where the low grass will prevent the soil from being washed away from the trees, and even in these situations the ground must be tilled occasionally. Pasture between the trees.

Catch crops may be taken off the land for the first few years, or until the limes are bearing, but as the lime roots run close under the surface, nothing should be planted too near to the trees. Beyond removing all suckers, dead branches, and those that lie too close to the ground, no pruning is necessary, indeed, the cultivation of the lime-tree is simplicity itself, for the more the plant is left to its natural growth the better will be the results. Catch crops. Pruning.

Manuring will be necessary to keep up the fertility of the soil, farm-yard manure being the best; and failing that, some special nitrogenous and potash manure may be employed. The author of this book, on his lime plantation in Dominica, had the skins and pulp of the fruit, after the juice was expressed, put on the roots of the trees so as to give back to the soil as much as possible of the produce raised from it. This system answers remarkably well, and it has been adopted by other planters. When the juice is concentrated and wood is used for fuel, the ashes from the furnace should be applied to the roots of the trees, for, as was pointed out in the first part of this book, wood ashes contain a large proportion of potash. Manures necessary.

Crops.—The yield per tree varies considerably, according to soil, tillage, rainfall and climate; but, with careful cultivation, a fair average soil, and a rainfall of about 60 inches *per annum*, from three-quarters to a barrel of limes can be reckoned on from each tree. The flowering usually begins in March, and the crop commences in June or July, and continues to December, but a few limes may be gathered all the year round, except at the end of the dry seasons, during which time vegetation is at rest. Yield per tree. Crop time.

The fruit to be allowed to fall to the ground.

Except when the fruit is exported, the limes should not be picked off the trees. They should be allowed to fall to the ground, and in this way the fruit is got in the best condition for obtaining the juice. On no account must the trees be shaken or beaten to cause the limes to fall, for the crop would then be lessened, by many flowers and much young fruit being thrown down.

Squeezing out the juice.

Mills.

PREPARATION OF THE JUICE.—The juice is extracted from the limes in various ways, but the process of squeezing underlies them all. Cider presses are used in some places, the fruit being cut up before it is put in the press. Small sugar cane mills are used in other places, and they do the work remarkably well. The best form of mill is one made with heavy horizontal wooden rollers covered with sheets of copper roughly perforated so as to *catch* the limes. With a good press or mill from seven to eight gallons of juice can be obtained from every barrel of limes; but, sometimes, on account of defective machinery, no more than five and a-half or six gallons are got.

Quantity of juice to a barrel of limes.

Necessity of cleanliness.

When the juice is exported in its raw state, it is necessary to take particular care to exclude all dirt, fruit pulp, and seeds. If the limes be gathered in rainy weather the mud must be washed off them before they are passed through the mill, and it is well to strain the juice through several copper sieves with meshes of decreasing size. Another good plan is to allow the juice to remain in puncheons or casks with a tap put in about 10 inches from the bottom. The juice will then "settle," the seeds and the heavier part of the pulp falling to the bottom, and the oil and other impurities rising to the top. The juice can be drawn off in three or four days, and it is allowed to run as long as it is clear. The casks in which the juice is exported must be completely filled, so as to exclude the air, and they should be bunged up as soon as possible. If this system be adopted the juice will remain in good condition for many months. When it is

Straining the juice.

Packing the juice.

necessary to keep it for a long time, half an ounce of salicylic acid can be added to every fifty gallons of juice, the acid preventing the fermentation and consequent destruction of the product. The salicylic acid will not interfere in any way with the wholesomeness of the juice. Prevention of fermentation.

CONCENTRATION OF THE JUICE.—Concentrated lime juice is prepared very simply by evaporation in open copper pans until the required density is obtained. In Dominica, the juice is usually boiled down until it reaches one tenth or one twelfth of its original volume—the resulting product, which will contain over 100 ounces of citric acid to the gallon, being a very acid stuff about the colour and consistency of molasses. The concentration of the juice requires a great deal of fuel, about two cords being required to produce a hogshead at a density of 10 to 1. It is necessary for the planter therefore, to look to the available sources of supply of fuel before he commences to cultivate limes for concentration of the juice. If he has no forest land on or near to his property, fast-growing trees should be planted at the same time as the limes, and the cultivation of trees for fuel should go hand in hand with that of the limes. How the juice is concentrated. Fuel.

The method of concentration over open fires is still in vogue on some of the smaller estates, but larger plants now concentrate by steam heat. The loss of citric acid in the open-fire process is from 10 to 20 per cent., but only about 3 per cent. by the steam process.[1]

GRAPE-FRUIT OR POMELO (*Citrus decumana* var.)

The "grape-fruit"—so called from the fruit growing in clusters like grapes—is a variety of the "shaddock"; commonly cultivated in India, West Indies, Tropical America, Florida, California, South Africa, &c. They find

[1] Warneford, Proc. West Indian Agric. Conference, Jamaica, 1925, p. 121.

a ready sale in America, and are growing in popularity in this country.

Commercial varieties.

There are several varieties, of which it may be sufficient to mention "Marsh," described by Coit as the chief variety of pomelo grown commercially in California and Arizona; "Imperial," one of the best keepers and shippers, a strong, upright-growing tree and a heavy cropper, and "Duncan," "Triumph," "Walter" and "Hall," vigorous growers and prolific bearers.

Cultivation as for the orange.

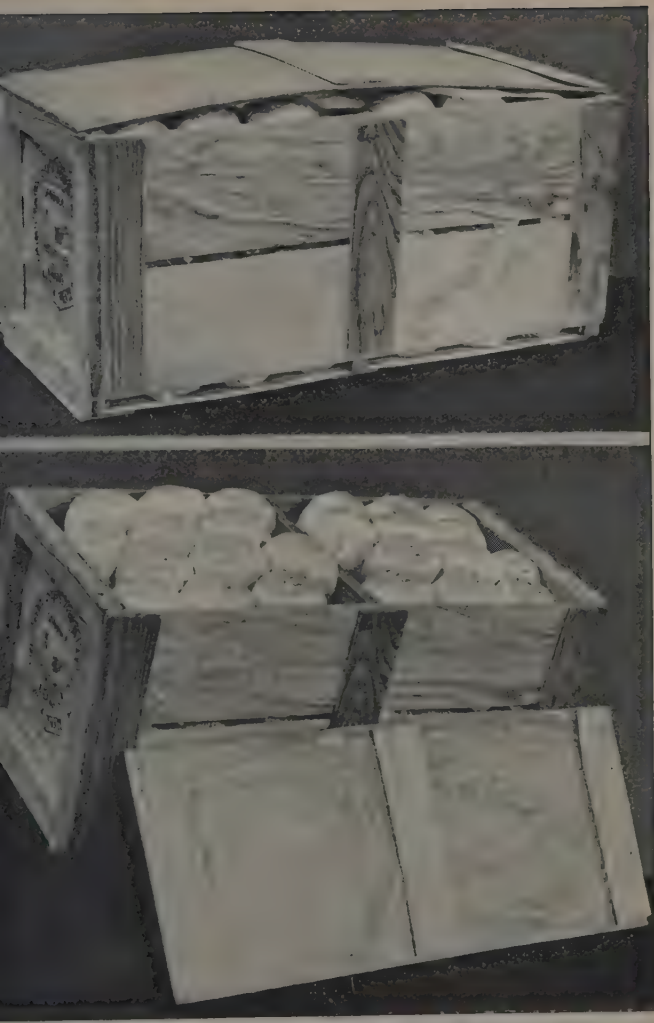
The cultivation of this group will be much the same as for that of the orange. May be propagated from seed; but to maintain a certain stock without variation it is advisable to propagate by budding and grafting. The best stock is usually considered to be the "Seville" or "Bitter" orange. Seedlings may be transplanted from the nursery beds to distances of about 4 feet by 3 feet, when about 18 inches high or six months old. Any distance apart from 12 to 20 feet may be required by the trees at maturity.

Packing.

The boxes and packing as illustrated on p. 221 are the same as for orange, described on page 212, the contents of each case varying according to size from 28 fruits ($5\frac{1}{4}$ inches diam.) in 3 layers to 96 fruits ($3\frac{5}{8}$ inches diam.) in 4 layers. The bulge in the centre of the lid must not exceed $2\frac{1}{4}$ inches. It is important that the boxes should be well made and strong in proportion to the weight carried.

Market prices.

The prices per case on the London market (Covent Garden) about Christmas time 1926 were 23*s.* 6*d.* for Porto Rico fruit, and 24*s.* to 30*s.* for Florida fruit. In June 1927 consignments from Florida ("Blue Goose" brand) were realising 50*s.* a case; other marks (Bristol market) 27*s.* 6*d.* to 35*s.*, South African (Brentford market) 15*s.* to 20*s.*, and Californian (Liverpool) 14*s.* to 20*s.* per case. The total imports into this country amount to more than £0,000 cwt. annually.



THE FLORIDA CITRUS BOX, PACKED WITH "GRAPE FRUIT," SHOWING AMOUNT OF BULGE.

[*From "Cultivation of Citrus Fruits," by H. H. Hume.*

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CHAPTER VII

FRUITS (*continued*)

THE BANANA.—*Musa sapientum. M. Cavendishii.* THE PLANTAIN.—*M. paradisiaca.*

OF all the vegetable productions of the world, the banana is, perhaps, in regard to magnificence combined with utility, the most wonderful. Its grand, herbaceous so-called stem, composed of the succulent leaf-stalks rolled one over the other, and its splendid crown of enormous light green leaves radiating from the centre—from which issues the bunch of fruits gracefully curving downwards, make it one of the glories of the tropics. The fruit of the plantain supplies food for multitudes of people, indeed it is "to the inhabitants of the torrid zone, what bread and potatoes are to those of the north temperate zone." It is rich in those substances necessary for the nourishment of man, and it has been said that a pound of plantains contains "more nutriment than three pounds of meat, whilst as a food it is, in every sense, superior to the best wheaten bread." But not only is it so valuable in regard to its nutritious qualities, it is also the most prolific of all the food plants known. Humboldt, the great German traveller and naturalist, calculated that thirty-three pounds of wheat and ninety-eight pounds of potatoes require for their growth the same space of ground as will produce 4,000 pounds of bananas.

Description of the banana.

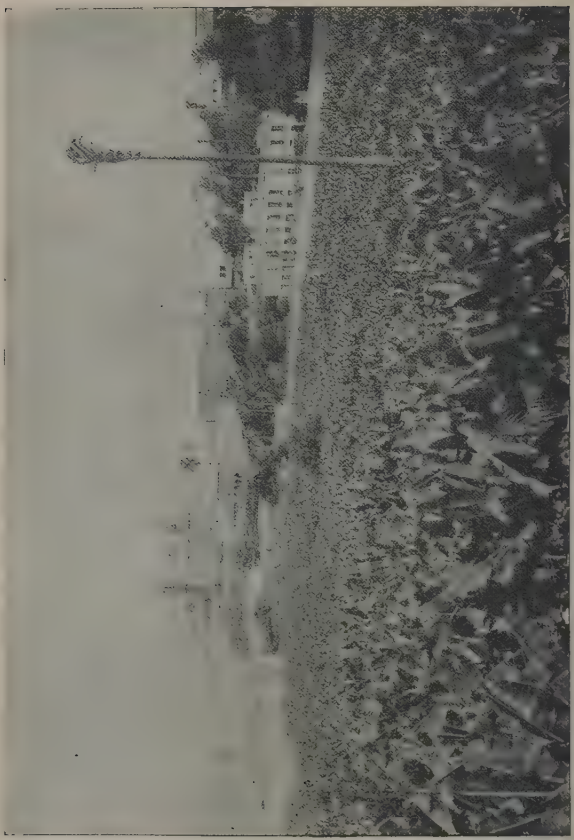
Its uses.

Its nutrient qualities.

Its fruitfulness.

BANANA FIELD ("GROS MICHEL"), JAMAICA.

BANANA IN FRUIT (*Musa sapientum*, VAR. "GROS MICHEL").
[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*



FIELD OF "CANARY BANANA" (*Musa Cavendishii*).

The banana and the plantain, sometimes classed as two distinct species of the genus *Musa*, are considered by many botanists as simply varieties of the same plant, which is a native of both the old and the new world tropics. The plantain is usually eaten unripe as a vegetable, and is not exported to any extent. The banana, however, is a fruit esteemed highly by the inhabitants of cold as well as hot climates, and it is exported from the West Indies and Central America, Costa Rica and other areas in great quantities to the United States and Europe. Jamaica is now the centre of the banana trade of the West Indies.

Habitat.

The banana trade of Jamaica.

There are a great number of varieties of the banana, as might be expected when it is remembered that the plant is cultivated throughout the whole tropical world—on different soils, in different climates, and under different conditions. The kinds most liked, however, in the American markets are the Martinique variety with its large yellow fruits, and the Cuban variety, which has shorter and thicker fruits with a dull red skin. The Martinique kind is now the principal one exported, and it is known throughout the trade as the Jamaica banana. In Dominica it is called "*Figue la rose*," and in Trinidad "Gros Michel" banana. The banana is often called "fig" or "figue" in the West Indies. Botanically it is *Musa sapientum*, var. "Gros Michel," and the plant grows 18–20 feet high. Unfortunately, however, this banana seems to be going rapidly out of favour owing to the ravages of the Panama disease—due to a *Fusarium*—against which no definite remedy has, so far, been discovered. The solution of the problem seems to lie in either the development of a resistant strain of the "Gros Michel" or of a new banana, and to this end experiments are being made in Trinidad and elsewhere. Amongst possible substitutes believed to be resistant to the disease is the suggestion to extend the cultivation, wherever possible, of the already well-known "Canary" banana (*Musa Cavendishii*), also known as the Chinese or dwarf banana,

Varieties.

—a native of China; cultivated in the Canary Islands and Barbados, in Jamaica, Trinidad, Brazil, Mauritius,

THE ROOT SYSTEM OF A JAMAICA BANANA PLANT SHOWING A "SWORD SUCKER."
Proportions indicated by the two-foot rule.
[*From "The Banana," by W. Fawcett.*

Seychelles, Fiji, Samoan or Navigator Islands, and in many other tropical and sub-tropical countries. The plant grows only 4 to 6 feet high, and comes to maturity in from twelve

o eighteen months. There are varieties of tall-growing bananas similar in habit to "Gros Michel," such as "Giant Fig," "Lacatan," &c., which are immune from Panama disease, and scientists are at present investigating the possibilities of any of these replacing the "Gros Michel."

SOIL.—The banana will grow in nearly every soil, except those composed almost wholly of sand or of calcareous matters, although even in these situations the plants will struggle on and perhaps bear small bunches of inferior fruits. The best soil for the cultivation of the plant is a warm, well-drained, but rather moist, deep loam, with a good proportion of humus. In such a soil, and with a favourable climate, bananas will yield enormous crops. The best soil.

CLIMATE.—The banana is essentially a tropical plant, and thus it will not bear a cold climate, but many varieties do extremely well at moderate elevations in the mountains, provided they are protected from the withering blasts of high winds. The banana will bear a cooler climate than the plantain, but both do best, and fruit earlier, near to the sea coast, an atmosphere impregnated with salt having no deleterious influence on the plants. Hot climates necessary.

PROPAGATION.—The underground stem of the banana sends off a number of side shoots, or suckers, which if left to themselves will grow up into a variety of stems, and in badly cultivated plantain walks it is not unusual to see a clump of a dozen or more stems growing from the same root stock. The banana seeds only in very exceptional instances, indeed so few people have seen the seed that it is believed by most persons not to occur at all. Fortunately, however, the plant is easily propagated by the suckers which are detached from the stem by means of a cutlass or a sharp spade, the earth being first of all removed carefully so as to expose the junction of the off-shoot with the parent plant. The best size of the sucker for planting is about two feet over all, Suckers. Seed. Cutting the suckers. Size of the suckers.

or for general purposes "maiden-suckers"—several months old—in which the foliage is well developed are advised; they are cut down at an angle to within about 6 inches of the bulb, the cut surface being about 8 to 12 inches across. Suckers with "sword" or first leaves are not recommended.

PREPARATION OF THE LAND.—The weeds having been hoed up, and the bushes and roots of trees stumped out, the land should be dug with hoes or well ploughed where possible. On hill sides and on broken ground the weeds may be buried in trenches dug with the hoe, for it is far better to bury the weeds than to burn them on the land, as by the latter plan a considerable portion of the plant food is carried off into the atmosphere. If the land be sodden with moisture, it may be drained by trenches being dug, as is explained in the chapter on drainage; and, where the soil is dry and water is available for irrigation, the cultivation will be immensely improved by carrying irrigation canals through the land, in such a way as to distribute the water as equally as possible. The water must not be allowed to run continually; but in such a matter as this, a little observation will soon enable the planter to decide on the proper time to stop the irrigation. When the plants are fruiting it will be advisable to turn off the water, as too much moisture at this time is disadvantageous.

The weeds to be buried.

Drainage.

Irrigation.

PLANTING OUT.—The suckers should be set at distances of not less than fifteen feet from each other. A good system is to plant in rows eighteen feet apart, the plants in the rows being at distances of fifteen feet. This will give about 160 plants to the acre for the tall Jamaica banana; but the dwarf Canary banana may be planted upwards of nine feet apart or about 530 plants to the acre. Between each third or fourth row, a drainage or an irrigation trench may be dug, all such trenches being made before the plants are put out. The sucker must be planted a foot deep in a specially prepared hole; and, when the land is poor, a little

Distances.

Holing the land.

manure can be put at the bottom of the hole. When planted, the earth should be firmly pressed down by the feet all round the sucker, so as to prevent the entry of too much air to dry up the roots when they shoot forth. By some planters it is advised to plant the suckers in a planting direction, but this is a bad system, and has nothing whatever to recommend it. The so-called stem of the plantain and banana grows up perfectly straight, and when the young plant is out of the perpendicular, a portion of the energy of growth is expended in the effort to straighten the stem.

Set the suckers straight in the ground.

CULTIVATION.—There is perhaps no tropical plant easier of cultivation than the banana. The suckers having been planted out at the commencement of the rainy season, they will grow vigorously and produce fruit in about a year. The land must be kept free of weeds; and an occasional turning up of the soil will prove beneficial. Before the plant throws out its flowering stem, suckers will make their appearance above the ground and these will require careful attention. Whilst the plant is young all the suckers except one should be cut away, the best plan being to sever them with a sharp spade. Thus all the vigour of the plant is thrown into the fruiting of the first stem and the growth of the one to supplant it, and in this way fine large bunches can be reckoned on. Afterwards, when the stool has matured, from three to five stems may be allowed to grow; but, on no consideration, should a larger number be permitted to shoot up—if fine bunches of fruit are looked for. The second stem usually produces a finer bunch of fruit than the first, but as the land becomes exhausted, the bunches, of course, decrease in size, and this shows the necessity for manure in some form or other. After the stool has borne a crop or two, the earth should be loosened round the stems, and manure or decayed leaves and banana stems forked in, the whole being moulded

Crops.

Cutting out the suckers.

The number of stems.

The size of the branches of fruit.

Moulding up.

up with surface soil from the vicinity. When the stool show signs of exhaustion, as it probably will after a few years, Replanting. should be stumped out, and a fresh sucker planted in it place, or better still in the intervening space between th former stools, the fertility of the soil being restored by a fre application of manure. When the land is intended to b kept in permanent banana cultivation, a good plan—afte lining out—is to plant each alternate hole one season, and t plant the vacant spaces another season. In this way th stools will not become exhausted at the same time, and by judicious application of the system continuous crops may b expected. The chief drawback to this plan is that the lan at first carries only one-half the usual number of plants while the cost of weeding and cultivating is much th same.

When the crops are gathered. CROPS.—With proper cultivation, a good soil, and a suit able climate, the first crop may be gathered in about a yea from the time of planting; and, as some plants may be back ward whilst others are forward in growth, bunches will be gathered at all times thereafter. The bunch must be cut Cutting the branches of fruit. with a portion of the stem for the convenience of the hand ling, and the terminal flower-buds should be removed at the same time. The trunk must then be cut down to within a few feet of the ground, and if it be chopped into short lengths, and arranged around the remaining trunks, it will rot and The fruit not to ripen on the plant. help to manure the soil. The fruit should be cut about a week or ten days before it is ripe; and, from the time it leaves the stem until it is placed in the market, it must be Careful handling essential. handled with the greatest care and gentleness, otherwise its value will be much lessened. An immense quantity of fruit, worth a very large sum of money, is lost every year by care- Bruised fruit. less and rough handling—a bruise that may not be apparent at the time, will soon cause decay of the delicate structure of the fruit, and this decay, once set up, is liable to spread to other fruit in the vicinity. In fruit culture one of the first

things to learn is care in the handling of the produce, and the planter will have to be constantly on the alert to see that his labourers exercise this necessary care.

Packing for shipment.

The "Jamaica" or "Costa Rica" banana is usually exported without individual packing, in ships especially fitted for the purpose with cold storage ; each bunch is stood on the cut end as closely as possible without crushing in the holds, whence they are loaded and unloaded singly on revolving hoists, being conveyed to and from these by hand. The "Canary" banana is packed with much greater care, being usually packed separately with dry banana leaves in wooden crates, or in baskets made (in the Canary Islands) of the "Common Reed" or "Spanish Cane" (*Arundo donax*, Linn.) ; or the bunches are packed first of all in cotton wool, with further covering of newspaper and straw, and finally in dry banana leaves, the whole being rammed tight before the crate or basket is tied down. They are carried in open holds or on the decks of the ships.

The Canary method of packing is popular in the trade and may be generally recommended for this species, the fruit being too tender for transport by ship without protection. The returns of imports are usually given in bunches, which in the case of the Jamaica variety may contain from nine to fifteen hands of with ten to fifteen fruits to a hand, averaging one hundred and twenty to one hundred and eighty fruits. In some instances it may exceed this, but the minimum for a standard bunch should not be less than nine hands. The Canary banana bears on an average twelve to fourteen hands, or about two hundred to two hundred and fifty fruits to the bunch, and the individual fruits are much smaller. Jamaica exported eighteen million bunches in 1926, and it is claimed to be the greatest banana-producing country in the world. This island and the Canaries are two of the chief sources of supply to this country, the total imports amounting to nearly five million bunches out of a total from all sources of more than ten million bunches a year.

Volume of trade.

BANANAS IN CRATES READY FOR SHIPMENT, BARBADOS.
[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

Bananas are used extensively as shade for young cacao trees; and in places where an export banana trade has been established the formation of a cacao plantation is a very inexpensive matter, as the return in fruit from the bananas will pay for the cultivation of the cacao until the trees are able to give a small crop. Bananas as shade plants.

THE COCO-NUT. *Cocos nucifera.*

AMONGST the remarkable trees of the tropics, the first to strike the attention of a stranger are the palms. The long and usually straight stems, crowned with tufts of most graceful green leaves waving in the breeze, is a sight that the northern traveller never forgets. The coco-nut has been rightly called "the prince of palms," for although it is, perhaps, not the finest of this most beautiful family of plants, yet in regard to its utility to man it is unsurpassed by any of the productions of the vegetable kingdom. The uses of the coco-nut palm and its products are many, and one has to go to the East and to the coral islands of Polynesia to realise the many uses of this palm. The beauty of palms. The prince of palms. The many uses of the coco-nut palm.

Every part of the tree is put to some good purpose. The roots are used as a remedy for fevers, the trunk is used for house-building, boat-building, and for making furniture; its hard outer portion is known in England as "porcupine wood," and it is highly esteemed on account of its beautiful grain. The leaves are used for thatching houses, and for making baskets, hats, mats, and other such articles. From their foot stalks combs are made. The fibrous net-work at the base of the leaves serves for sieves, and some of the natives weave it into clothing. The flowers are used as a medicinal astringent: from the cut flower-stalks palm-wine or "toddy" is obtained in great quantity; and in Ceylon, a spirit called "arrack" is distilled from the toddy, which to the native is what rum is to the West Indian. From the unfermented toddy, sugar, called "jaggery," is procured; vinegar is also The roots. The wood. The leaves. The flowers. Arrack and toddy. Jaggery sugar.

one of the useful products obtained from the juice. The fruit is well-known and highly esteemed in all parts of the world. The husk produces coir, from which ropes, cordage, mats, brooms, brushes, bedding and other useful articles are manufactured. The hard shell is made into lamps, drinking vessels, spoons and such-like things. The white kernel (called "copra" when dried and exported), contains much oil (see p. 545).

The husk and the shell.

The kernel.

The kernel is a food product of great importance to the inhabitants of many parts of the tropics. Inside this there occurs a large cavity filled with a deliciously cool fluid which, when the nut is young, is used as an agreeable beverage and as a medicine in some complaints. The albumen of the young nut is a soft, jelly-like substance which is highly nutritious and of a delicious flavour.

The milk.

Desiccated Coco-nut is a preparation that is of growing importance in the countries of production. It is essential to use only fresh ripe fruits. The nuts are first husked, then sterilised by steaming in a kiln under low-pressure steam, a process which should take an hour or two; this will also have the effect of loosening the kernel to admit of removing the shell easily, after which the brown skin is pared off, the milk drained and the white meat shredded and dried immediately. Drying may be done on trays in a hot-air chamber, stirring the shredded nut meanwhile, until quite dry. It is then cooled and packed in lead-lined cases for shipment. This product is largely used by confectioners. It realises 45*s.* per cwt. for medium, 47*s.* 6*d.* for threads, and 41*s.* per cwt. for chips on passage.

Desiccated coco-nut.

A singular and highly-prized pearl is found under very rare circumstances in coco-nuts, and a specimen is to be seen in one of the Museums of the Royal Gardens at Kew.

The coco-nut, in the same way as the banana and other plants that have been cultivated in many different countries from ancient times, has many varieties, but the differences consist principally of variations in the size, shape and character of the fruit. In some instances the fruit is small

Varieties.

and round, in others large and oblong. It is divided into three well-marked ridges. In some, again, the fibrous envelope is developed largely at the expense of the nut, and in others the reverse obtains. In countries where the coco-nut palm is cultivated, all these and other differences may be observed by any intelligent person.

Alluvial soils the best.

SOIL.—The alluvial soils such as may be found near mouths of rivers, provided they are well drained and prepared by ploughing, are the best situations for the cultivation of the coco-nut, as in these places the alluvium is usually rich and deep. The next best soil is a brown loam which may be of a gravelly nature; then come the sandy soils found in abundance along the coast-line of the tropics, where in these sandy and apparently sterile soils the trees derive their nourishment from underground springs flowing into the sea. Coco-nut trees will not thrive on a clay soil nor on thin gravels; and it is useless to attempt the cultivation, with the expectation of profits, on any but a suitable soil.

A maritime climate necessary.

CLIMATE.—It is said that the lowest average temperature that the coco-nut will thrive in is 80° Fahrenheit, and that the annual rainfall must be at least seventy inches; but the trees will grow and give crops at a lower temperature, and with less moisture. The climate, however, must be a humid one, the palm delighting in the very moist atmosphere of the sea coast. It is difficult to say without reserve if the tree is essentially a halophyte: probably not, seeing that it does not thrive in swamps and has been found to do well in situations distinctly free from the influence of salt. It does not object to salt water occasionally and is not usually found many miles inland. Sea breezes are not inimical to the growth of the palm and for this reason it may well be used to protect other trees further inland. A writer on the coco-nut makes the following remarks in regard to the tree delighting in a maritime situation. He says the palm "flourishes so "very near the sea, that its roots are in many places washed

COCO-NUT SEED BED WITH YAMS IN THE BACKGROUND.

"by its waters without injury to the tree, until it is actually "undermined. It is likewise remarkable, that those trees "which are nearest the shore all bend their heads towards "the sea, notwithstanding the violence of the south-west "winds, which blow incessantly from that quarter from "May to September inclusive; and the regular sea-breezes "which prevail in the day, during February, March, and "April. In addition to which circumstances, they are per-"fectly sheltered from all winds blowing on the land side."

The palm delights in the sea breezes.

PROPAGATION.—The coco-nut palm is propagated by seed, ripe nuts being sown in nursery beds until they germinate, and then they are planted out in the places where the trees are to grow. The greatest care must be exercised in obtaining good ripe nuts for seed. It is well to select a healthy middle-aged tree and to allow the nuts to ripen on it for seed. When the nuts are thoroughly ripe they must be picked before they become dry, and then kept for a month before planting, in order that some of the moisture may be absorbed and the outer skin rendered water-proof. The nursery beds must be made in a sheltered place where the soil is light, and the earth must be dug up to the depth of two feet—all stones and roots being removed. Trenches should then be made about six inches deep and the nuts laid in them on their sides with the stalk ends slightly raised, an interval of about a foot may be left between each nut. As much earth is then returned into the trench as will cover all but about two inches of the crown of the nuts, and over all should be laid about six inches of straw or grass or cane-trash. In some countries where the atmosphere is perennially moist the ripe fruits are merely laid on their sides without any covering except the shade of mature trees. Many seeds may not germinate, or they may produce weakly shoots, so that it is well to sow fully 50 per cent. more nuts than the number of plants desired to place out in the field. An occasional watering is necessary in dry weather, and the

Care to be observed in the selection of seed nuts

Nurseries.

How to sow the seed.

The nurseries to be watered.

All the seeds will not germinate.

TREE SEVEN YEARS OLD. YOUNG PLANTS IN BACKGROUND.
Phaseolus lunatus as a cover-crop.
[*From "The Coco-nut," by E. B. Copeland.*

urseries must be kept free of weeds. Germination is usually isible in three months after sowing, and in from five to eight nonths the plants will be ready to set out. Nuts that are ardy in germinating should be rejected. The time of germination.

PLANTING OUT.—The land must be lined so as to give a lear space of thirty feet between each tree, since if planted loser the leaves will interlace, and the crops will be lessened. The usual distance is half-a-chain or thirty-three feet between ach tree, giving forty trees to the acre. Holes, two feet deep nd three feet wide, should be dug some time before the plants re put out, and the earth taken out of the holes must be eaped all round the margins so that it may gradually be vashed down to the roots of the growing tree. The holes, fter being allowed to remain open for a time, are to be illed with surface earth to within eighteen inches of the evel of the land when the seedling is planted, thus the crown f the young tree is half a foot below the level of the ground, ut in the process of time this becomes filled up, and so nsures a deep and firm hold of the ground by the roots of he plant. Distances. Holes, not to be filled entirely.

CULTIVATION.—After the plants are firmly rooted in the ground, very little cultivation is required beyond keeping he land free of weeds for some little distance round the oung tree. Many planters recommend that cattle should e allowed to graze amongst the trees, but if this system be dopted the young plants will have to be fenced in so as o prevent the cattle from eating up the leaflets of which they re very fond. Catch crops such as maize, cassava, potatoes nd such like may be taken off the land when alluvial loams re planted with coco-nuts, but it must be remembered that hese crops tend to impoverish the soil and an effort should e made to return in manure what has been taken away by atch crops. Where necessary the land should be irrigated, s the young plants require a great deal of water to bring hem rapidly into bearing and to produce vigorous and Weed round the trees. The grazing of cattle. Catch crops may be raised. Irrigation.

When the trees begin to bear.

healthy trees, but usually a good soil mulch is all that is necessary. In good land, and with careful cultivation, the trees will begin to flower in the fifth year, or even earlier in some instances, but the full bearing will not commence before a period ranging from the seventh to the twelfth year from planting, and thereafter until about the twentieth year the crops will go on increasing provided a proper system of cultivation be kept up.

No definite knowledge is available as to how long a tree will continue to be profitable without replanting, but if cared for a plantation will last for at least forty-five years. A well-grown tree is shown on p. 240.

ENEMIES OF THE TREES.—Fortunately the coco-nut palm has not so many enemies in the West Indies as in the East, but great attention must be paid by the coco-nut planter to the cultivation, so as to detect at once the ravages of any blight or animal that may be injuring the trees or ruining the crops. It is the old story of a "stitch in time saving nine." A disease, taken at the commencement of the symptoms, may often be easily overcome; but if it be allowed to make progress, it will often defy every remedy.

Scale blight.

In some places the leaves of the coco-nut palm are attacked by a scale insect (*Aspidotus destructor*), easily detected by careful examination. Little scales are seen closely applied to the leaves; after a time the leaves attacked turn brown and die, and eventually the plant may be killed. Such blights are prone to attack weakly trees planted in unsuitable situations and badly cultivated, but sometimes they invade healthy trees, properly cultivated, in the best soils and climates. When a few trees only are affected they may be cut down and destroyed by fire. Or the following emulsion, used to kill the scale insect on orange trees, may be applied to the affected leaves :—

Affected trees to be destroyed if they are not numerous.

Insecticide.

Kerosene	2 gallons
Soft Soap	½ pound
Water	1 gallon

The soap is dissolved in the water, which should be boiling, and the solution mixed with the kerosene. The mixture should then be churned up with a large "swizzle" stick, until it forms a cream. Before using, one part of the emulsion is diluted with nine parts of cold water.

"Rhinoceros beetle" (*Oryctes rhinoceros*) which destroys the young plants before they come into bearing, is found in many countries. This beetle feeds on the terminal bud of the palm, and thus kills the plant. Where possible this pest must be dug out and destroyed, and it has been recommended that slaked lime or salt should be freely applied to the bud of the tree as a protection.

Rats.

The crops are often much lessened by the attacks of rats which easily climb the trees and destroy immense numbers of the young nuts. The depredations of the rats may be easily prevented by covering the trunks of the trees to an extent of twelve inches with sheets of tin or galvanised iron, or the rats are unable to climb over the smooth metal. Of course the trees must be freed from rats before the metal sheets are nailed on, and to do this the nests should be destroyed and poison freely placed amongst the bases of the leaves. It is of no use protecting a few trees. The whole plantation must be done, as in a grown plantation rats can easily travel from one tree to the next.

How to prevent their ravages.

Returns.

CROPS.—The yield of nuts depends on soil, climate and cultivation, and, as may be imagined, the crops of different trees vary widely. In Ceylon it is said that the general average return of coco-nut estates is not over thirty nuts per tree; but individual trees have been known to give over 300 nuts every year for a period of ten years. This enormous yield, however, is most exceptional; but with a good climate, a fair average soil, and judicious cultivation, the return ought to be at least seventy nuts a tree, and at thirty feet distance this would give a yield of 3,500 nuts per acre. By the application of suitable manure the returns may be considerably increased.

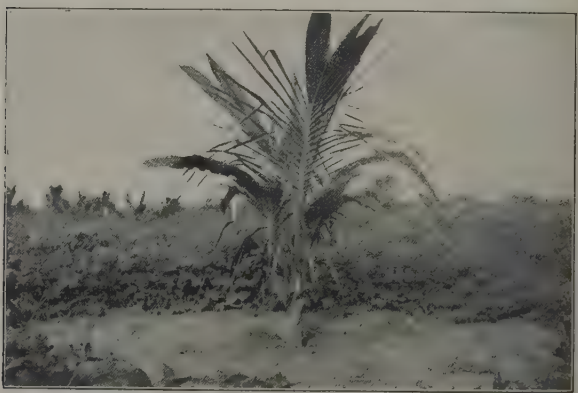
COCO-NUT RAFTS.

[*From "The Coco-nut," by E. B. Copeland.*

Harvesting. In some countries the ripe fruits are merely allowed to drop of their own accord, but in others this is not advisable as the fruits do not always fall when ripe and may germinate on the tree. In many countries the bunches of ripe nuts are harvested at regular intervals. Skilled workmen are employed, who climb the trees and who can tell by tapping the fruit whether the bunch is ripe or not; the sound indicates the state of dryness of the husk, which dries as it ripens.

Husking. The process of husking is laborious but is not difficult, and a practised workman can husk 2,000 nuts in a day. The husk is levered off by piercing one of the faces of the fruit on the flattened point of a crow-bar or hoe and levering it sideways. The same is done on the next face and the whole husk then easily comes away. Fruits are usually husked before being shipped and are now generally put up in bags. It is sometimes convenient to raft the nuts to the port of shipment.

Rafting nuts (see p. 245).



COCO-NUT PLANT, FIRST YEAR IN FIELD.
Phaseolus lunatus as a cover-crop.
[*From "The Coco-nut," by E. B. Copeland.*

The commercial products of the coco-nut palm are the whole fruit or nuts, the desiccated kernel as described above, oil expressed from the kernels, and coir-fibre obtained from the husk. For particulars of the oil and fibre see the chapters on these subjects. Apart from these the trade in the whole nuts is of some importance. Ceylon, one of the principal countries of production, exports on an average twenty millions a year, whilst approximately one thousand million fruits a year are utilised in the island for the extraction of oil, preparation of copra and manufacture of desiccated kernel. Trade in fresh nuts.

THE DWARF COCO-NUT. *Cocos nucifera*, var.

A dwarf coco-nut which is known in the Federated Malay States as "nyiur gading," is remarkable for its early fruiting, palms only ten feet high bearing abundant fruits touching the ground. The young palm grown under good conditions starts to flower in its third year and produces ripe fruit in about nine months from the appearance of the flower spike. The first spikes contain only male flowers, but other spikes appearing in rapid succession are larger and bear an increasing number of female flowers also, a spike from a six-year-old tree being found with two hundred young female flowers, whilst trusses of fruit from similar trees have been found with as many as fifty-five ripe nuts. The colour is bright yellow, though this is said to vary to orange, red and green. Habit.

This palm is said to thrive in any soil provided the drainage and rainfall are good, though well-drained alluvium is considered the best. It is possible to plant this small palm about ninety to the acre, calculated to yield, five years after planting out, over 2,000 nuts, and after nine years over 10,000 nuts per acre. In Malaya the fruit is preferred by the natives for domestic uses—it is said to be richer in oil and sweeter in taste than that of the larger tree (see under Oils and references to Malayan Agric. Journ. at end of chapter). Soil. Yield.

The Pine-apple. *Ananas sativus.*

Hot-house pines.

The pine-apple trade.

Cultivation in the West Indies and other colonies.

Habitat.

Varieties.

The pine-apple is universally acknowledged to be one of the most delicious fruits in existence. Before the wonderful strides made in rapid passages between Europe and tropical countries by steam vessels, great numbers of pine-apples were grown in hot-houses for the home markets: and to such a degree of perfection did gardeners attain in this industry, that the English hot-house pines were considered to be the finest in the world. But now a large and increasing trade has been built up by the exportation of pine-apples from the West Indies and elsewhere, to the great fruit markets of England and the United States. Indeed, in the Bahamas, the cultivation of the pine-apple is one of the chief industries of the colony, and the cultivation has been extended to tropical Africa, Queensland, Ceylon and many other hot countries. The pine-apple is a native of tropical America, but it has been greatly improved by cultivation—some of the finest varieties being the Jamaica Ripley, the Black Antigua, the Queen, the Sugar-loaf, and the Smooth Cayenne.

The best soil.

Lime in the soil advantageous.

Soils.—The best soil for the cultivation of pine-apples is a sandy loam with good drainage, and next come the free sands and gravels. Clay of all kinds, and badly drained lands are unsuitable to the cultivation, but the plant can be successfully grown on red, loamy clays, if the land be well tilled and properly drained. A good proportion of lime is advantageous; the soil of the Bahama islands, where the pine-apples are grown, consists of decomposed coral rock, and, in Antigua, a considerable portion of the soil is formed from broken-down limestone.

Climate.—The coast zone of the West Indian islands may be taken as the typical climate for pine-apples, for the plant in an apparently wild condition is found in Dominica and others of its sister colonies. Pines will grow at high

elevations in the mountains, but the fruit is not so fine, nor of so delicate a flavour, as that produced in the plains and the lower spurs of the hills. Mountain climates unsuitable.

PROPAGATION.—When a pine-apple plant has borne its fruit, a number of suckers are formed around the parent root-stock, and each of these suckers, when detached and planted, will produce an independent plant. Separate plants may also be grown from the crown of leaves that rises above the fruit, but it is hardly worth while doing so. Many pine-apples contain seeds, which appear as little black or brown bodies buried in the fruit near to the skin, and plants may be obtained by sowing these seeds. Some of the finer varieties have been produced from seed by English gardeners; but, commercially, the best and quickest mode of propagation is by suckers. Suckers. Crowns. Seeds.

CULTIVATION.—The land having been cleaned and weeded, it should be deeply ploughed, or trenched with the hoe or spade to a depth of at least two feet, all the weeds and rubbish being buried in the trenches. In lining, the distances should not be nearer than three feet, which will give nearly 5,000 plants to the acre. A better plan, however, would be to line out the land in rows six feet apart, and to plant the suckers at distances of three feet in the rows, this would allow nearly 2,500 plants to the acre; and, after the first crop, a few of the suckers, say four to each plant, could be left, and then this would give nearly 10,000 fruits for the second crop. The advantage of leaving a clear space between the rows is found out when the weeding and cropping operations are in progress; for, owing to the sharp prickles set at the edges of the leaves, the labourers experience great difficulty in the cultivation. In the Bahamas, the men, women and children, when working amongst the pine-apples, are compelled to protect their legs with strong canvas leggings, and their hands with heavy gloves to which gauntlets are attached. The plants must be kept free from weeds, and Lining. Distances. A clear space to be left between the rows.

properly moulded up, and when the dry weather comes on the roots should be protected by an application of leaf mould —which serves as good manure. Animal manure, unless perfectly rotted, should not be put near the plants, as it is inimical to their growth. After three or four years the plants will show signs of exhaustion, they must then be rooted up, and the land prepared for fresh plants. In lining, care must be taken that the rows are set off in land that was not occupied by the old plants, and the wide space that was left between the rows will enable this system to be carried out.

Manures.

Replanting.

CROPS.—The fruit will come to maturity in from eight to nine months from the time of planting, but it must be cut before it is ripe in order that it may bear the sea voyage to the English and American markets. Every effort should be made to propagate those plants that bear early in the year, for far higher prices are paid for early pines than for late ones. The fruit must be cut, by means of a sharp knife, with a portion of the stalk attached, and every care is to be taken in the handling so that the pines may be shipped without bruises, for a bruised pine-apple will soon become a rotten one.

The pines to be gathered before they are ripe.

Careful handling essential.

PACKING.—This is a very important operation, for on it depends entirely the success or not of the industry. Usually pine-apples are shipped to the home markets in old flour barrels, holes being cut in the staves for the purpose of ventilation. But this is a very unsatisfactory method, as a large quantity of the fruit usually decays on the voyage. In order to get the pines to the markets in the best condition, boxes, similar to those described in the chapter on oranges, should be used. These boxes being made of laths with wide openings allow free ventilation; and, as they are divided into two compartments, each to contain either three or six pines only, the fruit is not bruised by pressure. The best pines having been selected, they must be carefully examined

Barrels.

Boxes as for oranges and grape-fruit advised (see pages 212 and 221).

PINE-APPLE "SMOOTH CAYENNE,"
SOMETIMES CALLED "THE KEW PINE."

[*From "Pine-apple Culture," by Hume & Miller, Florida Agric. Exp. Stn.*

FIELD OF CAYENNE PINE-APPLE.

[From "The Food Plants of the Philippines," by P. J. Wester (Bureau of Agriculture, Manila, Bulletin No. 39, 1925).

in order to reject bruised and ripe fruit, they are then wrapped in paper or maize husks so as to leave the crown of leaves free, and gently packed in the boxes and kept in a cool dry place until they are shipped. Bruised and ripe fruit to be rejected.

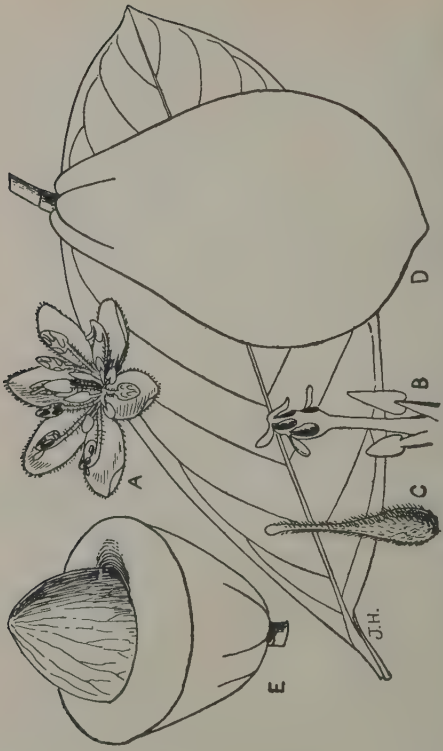
The pine-apples from Madeira and the Canary Islands, which arrive in England in such an excellent condition, are packed in light boxes with a separate compartment for each fruit. It may also be found advisable to ship in specially prepared crates containing from about eighteen to forty-two, according to the selected sizes of the green, though fully developed, fruit. The best way to pack the pines.

Perhaps the more important trade, however, is in the ripe fruit for canning purposes done on a large scale in Florida, Straits Settlements, Hawaiian Islands, chiefly with the variety "Smooth Cayenne"—sometimes known as the "Kew Pine." This variety is used almost exclusively in the Hawaiian Islands—one of the most important centres of the canning industry, and in Natal the "Queen Pine" is used. Canning pine-apples.

Avocado Pear. *Persea gratissima.*

A tree 20–30 feet or more high. Fruit pear-shaped or more or less globular, 3–4 ins. long, about 2 ins. through, containing one large seed. Description of tree.

The fruit comes occasionally into Covent Garden Market, but though widely spread in the tropics, the sub-tropical countries of California and Florida are the chief of the comparatively few places where it is cultivated on a commercial scale. There are numerous varieties, which have been classified broadly on their country of origin, degrees of hardiness, and value for commercial purposes—West Indian or South American, Guatemalan or Central American, and Mexican, the one suitable for the lowlands of the tropics the other for the highlands, and the third characterised by its greater degree of hardiness, and therefore need not here be considered. The West Indian varieties are recommended for purely tropical countries, especially at low elevations; Varieties.



AVOCADO PEAR (*Persea gratissima*, Gaertn.) (Lauraceæ).
A, flower. B, stamen. C, ovary. D, fruit. E, section of fruit.
[*From "Families of Flowering Plants," by J. Hutchinson.*

the fruits may weigh from a few ounces to two or three pounds. "Pollock," "Trapp," and "Waldin" are three varieties specially mentioned by Popenoe; all raised in

Florida. Amongst the Guatemalan varieties that may be recommended in the higher lands approximately to the altitudes suitable for Arabian coffee, say 2,500-3,000 feet, the same author recommends "Blakeman," "Dickinson," "Sharpless," "Solano," "Spinks," "Taft," all originating in California, and "Taylor," raised in Florida. They may be raised from seed, but naturally do not come true, and the best sorts are propagated by budding or grafting, usually on seedlings of the same group. Seedlings from the nursery may be put out in permanent places when about six months or a year old, or in the case of grafted plants as soon as these are well established, or about eight to twelve months old, when grafted on stocks two months old or thereabouts. A rich well-drained soil, a hot climate and a space of from 20 to 25 feet between each tree are necessary; the trees begin to bear in about five years, and in general the cultivation and requirements are much the same as for the mango, *Mangifera indica*, a tree which has been recommended in Hawaii as a wind-break for Avocado (Bull. No. 51, 1924, Hawaii Agric. Expt. Station), though as a food it is perhaps the more valuable of the two, as the fruit may be eaten both as dessert and in salads. Some care in pruning is required in the first instance, the aim being the development of a good head, remembering that the flowers and fruit appear towards the end of the branches. As the roots are largely surface feeders, manuring is perhaps best effected by mulching or digging in green manures. The fruit has been compared with the olive (*Olea europaea*) in its value for content of fat.

Soil and climate.

MANGO. *Mangifera indica.*

A large evergreen tree, native of the East Indies and Malaya; naturalised in tropical America, Asia and Africa. There are many varieties under cultivation which it would be quite impossible to even enumerate here. Certain varieties are popular in special localities, as in Ceylon, where the "Rupee" is considered one of the best, in Bombay

Description of tree.

INFLORESCENCE OF "ALPHONSE" MANGO.

[*From "Manual of Tropical and Sub-tropical Fruits," by W. Popenoe.*

e "Alphonse"; other superior sorts are "No. 11," Varieties.
Peters," "Malda," "Peach" and "Julie." Woodrow
ıdia) gives descriptions of eighty famous mangoes, and
her writers, with special reference to Trinidad, Jamaica,
eylon, &c., have recommended varieties that have come
thin their own experience or that have been found suit-
ble for a particular country. Propagation may be from Propagation.
ed, but the choice varieties are best propagated by graft-
g, usually on seedlings of the common stock, the inarching
ethod with pot-grown plants about one year old being a
liable method. There is little or no difficulty in growing
e ordinary mango for stocks, the seeds germinate quickly
in about a fortnight—if sown as they should be, as soon
possible after ripening; and as the mango makes a fine
enue tree, any surplus plants might be used to good
lvantage. Polyembryony is characteristic of many of the
edlings, but these can be discarded as soon as observed
ı germination. Grafted, budded or layered trees come to
aturity earlier by several years than do those raised from
ed. For the strong growers 20 to 30 feet will be required
etween each tree, and for the finer varieties about 12 to 15
et and upwards may be required. A rich, deep and Soil and climate.
ell-drained soil, a rainfall of 50 inches and upwards in a
opical or sub-tropical climate, are essential to good growth,
ore particularly in the early stages. But a dry season of
fficient duration to ripen the wood after growth is also
ry desirable, or in moist regions the practice of root
uning is sometimes resorted to, in order to check excessive
af growth and so encourage the development of fruit.
eavy rains at the time of flowering may often prevent
ollination and consequent failure of the fruit, and it is
nportant at this period to see that the soil is not over rich;
manuring is required, it should be done shortly after the
uit is set, to help development. The fruits are commonly
ten fresh, but large quantities are used in India for making
hutney, and in this and in other countries of production as

a preserve. Consignments of fresh fruits from India or th West Indies are not uncommon in Covent Garden, but th demand does not appear to be a large one, and the trade this fruit in comparison with oranges or bananas is insigni cant.

Date Palm. *Phœnix dactylifera.*

This palm is so well known as to need no descriptio It is perhaps better suited to sub-tropical conditions, suc as would be obtained at several thousand feet above se level in tropical countries, than to a purely tropical climat It is cultivated in the West Indies, in N. Africa fro Morocco to Egypt, extending to Mesopotamia, Palestin Persia, Arabia, India, and in California, Arizona, &c. is comparatively easy to cultivate, and requires a hot, dr climate with facilities for irrigation—a good supply of wate at the root being essential—and a rich, well-drained soi

Propagation by seed or offshoots.

Propagation by seed or offshoots—the latter being the bes more particularly so when it is desired to preserve true t type the good varieties of which there are many unde cultivation. Offshoots three to six years old, 6 lbs. or mor in weight, are recommended. As the tree is dicœcious it i essential to plant a few male trees at wide intervals in plantation for fertilisation, at least one male tree to ever hundred, or approximately one tree per acre of female trees It is difficult to distinguish males from females amongs seedlings, but in a paper on the Sex of Date Palm Seedling in Kew Bulletin, 1914, pp. 159–162, it is suggested tha male plants are stronger with stiffer leaflets, and that the grow more quickly than female plants. Trees raised fro suckers bear fruit in from four to five years, the yield in creasing up to about ten years old, when they may b regarded as fully grown ; they may continue profitable fo upwards of a century. Artificial fertilisation is usuall necessary, the correct period being determined by loca conditions. In Mesopotamia, an important date-growin centre (K.B., 1908, p. 284), the cultivator climbs the femal

Tree dicœcious, or male and female flowers on separate trees.

Pollination necessary.

DATE PALM IN FRUIT.

[*From "Manual of Tropical and Sub-tropical Fruits," by W. Popenoe.*

tree with a few sprigs of the male flowers cut from a spadi: and opening the spathe deposits these, or pollination migh be effected by dusting over with a muslin bag, containing the pollen that had been collected when quite dry an mature. During the flowering period the grower mus continually be on the look-out for opening spathes, unti all have been fertilised. Fruits ripen in about 150 days from fertilisation. Dates take a leading place in the commerce of this country and, in comparison with oranges and bananas from the more moist parts, are the only fruit tha can be grown successfully on a commercial scale in the dry regions of the World. Our principal supplies come from Asiatic Turkey, France, Egypt, Persia and U.S. America, to the extent, in 1920, of 1,147,346 cwts. (value £2,719,923), and in 1924, 95,206 cwts. (value £282,927). [Egypt was not included with foreign countries in 1920—the return being given under British Possessions up to 1924.] The imports from British Possessions (including Egypt) in 1920 were 22,579 cwts. (value £60,631), and in 1924 (excluding Egypt) 641,229 cwts. (value £638,759). Of the many varieties under cultivation, those grown for commercial purposes are "Amry" in Egypt and "Khadrawee," "Hallawee" or "Halawi" in Mesopotamia (Basra being an important centre for exportation to the United Kingdom, America, &c.), "Degletnour" and "Tafilat" in North Africa—chiefly Algeria and Tunis—"Zahidi" or "Zadie" (Popenoe) in Persia. There are other varieties with a smaller proportion of sugar that are eaten in a fresh, ripe state—"Saidi" being an important variety grown in Egypt.

Trade supplies.

Varieties.

Enumeration of fruits of secondary importance.

There are many more fruits that are grown in the tropics, but space forbids more than a mere enumeration here. They do not come into the home markets, except perhaps on rare occasions, and consequently are not generally known outside the countries of production. Given suitable conditions as to climate, they are not as a rule difficult to grow for local purposes.

GUAVA (*Psidium Guayava*).—A small tree, easily propagated from seed, suckers, or cuttings—grows freely and uickly, sometimes overrunning areas to such an extent as o become a pest. Begins to bear in two or three years, ruiting very profusely; largely used in the West Indies, 3ritish Guiana, &c., for making jelly. Native of tropical \merica, and naturalised in many tropical countries.

CASHEW (*Anacardium occidentale*).—A small tree, indigeious to South America and the West Indies: introduced to ropical Africa and many hot countries. The juicy, fleshy)edicel may be eaten when ripe, but of the real fruit, usually lescribed as a nut, it is only the roasted kernels that are ommonly eaten. Propagated by seed, and as it does iot transplant readily, the seeds (nuts) are best sown in)amboo pots if raised in nurseries, or sown at once in)ermanent positions. The tree thrives in regions where nost other trees would fail—in comparatively dry soil and small rainfall. In India it is grown in the coast forests in andy soil, and in S. India it is reported to be of value for reclaiming coast dunes.

ANONACEÆ.—The best of the *Anonas* is believed to be he CHERIMOYER (*Anona Cherimolia*); indeed, it has been lassed with pine-apple and mangosteen as one of the best; iative of the Andes of Ecuador and Peru. Propagated from eed, it succeeds in a fairly rich soil with plenty of moisture nd a sub-tropical climate. Accordingly, in tropical countries t would be best adapted to hilly districts; for instance, it is ultivated at the higher altitudes of Ceylon, and is also grown n a commercial scale in the Canary Islands and Madeira, whence, under the name of "custard apple," the fruit often finds its way to Covent Garden. The true "custard apple," or "bullock's heart," is *Anona reticulata*, grown in he West Indies. All the *Anonas* mentioned are small trees.

The SOURSOP (*Anona muricata*) is widely cultivated in

CASHEW NUT (*Anacardium occidentale*).

A, flower. B, same with petals removed. C, same in vertical section. D, fruit in vertical section.

[From "Families of Flowering Plants," by J. Hutchinson.

e tropics; propagated by seed, it grows freely in almost ny soil; and finally the "sweet sop" or "sugar apple" *Anona squamosa*) of South America and the West Indies, custard apple" of India, where it is reported (Woodrow, Gardening in India") to grow to perfection in the most ocky, hot, and barren parts of the country. In general ropagated from seed, it grows quickly, coming into bearing about three years, and grows in a deep, stony soil with lenty of humus and good drainage.

ROSE APPLE (*Eugenia Jambos*), a tree 20–30 feet high, f tropical Asia, very ornamental and easily grown from eed. Flowers white, fruit white, red or rose-coloured; eshy, but not very juicy.

GRANADILLA (*Passiflora quadrangularis*), a climbing lant, fruit greenish-yellow, native of tropical America and idely grown in the tropics, the fruit often coming into both 'aris and London markets. May be raised from seeds or uttings; the cultivation is easy with fairly rich soil and ood rainfall. Poles or trellis-work are advisable—though ometimes trees are preferred for support of the vines, which equire plenty of light and sunshine. The plant is a rank rower, and thinning out may be required during the rowing season; further, the fruit-bearing branches should e pinched back occasionally to encourage development of he fruit. "Mountain sweet cup" or "purple-fruited passion lower" (*Passiflora edulis*), native of Brazil, is easily grown n much the same way.

SAPODILLA or SAPODILLA PLUM (*Achras Sapota*) a ree 30–40 feet high and upwards, native of the West ndies and Mexico, cultivated for the fruit in many tropical ountries, both East and West. "Chicle gum" is obtained rom the trunks of wild trees, chiefly in Honduras and Mexico. Propagated by seed, cuttings, suckers or layers; rows freely in good, well-drained soil with an average rain-

fall, from sea level up to about 3,000 feet. In transplanting to permanent places a distance of 20–25 feet apart should be allowed.

The STAR APPLE (*Chrysophyllum Cainito*), closely allied to the "sapodilla," is a large tree upwards of 60 feet high. The leaves are remarkable for their glabrous dark green colour above and golden pubescence below. Native of the West Indies and South America. Propagated by seeds, and thrives best in a rich soil which requires to be deep and well drained.

BREAD-FRUIT (*Artocarpus incisa*), a tree 30–40 feet high. Native of the South Sea Islands. Introduced to tropical Africa, Asia, America, West Indies and Queensland. There are two plants known under the same botanical name, one, the "bread-fruit" without seeds, and the other the "bread-nut." The bread-fruit is usually regarded more as a vegetable, as it requires to be cooked before eating. The bread-nuts are boiled and eaten with salt, and in general they form an important article of food in all the countries into which they have been introduced. Propagated by means of seeds in the case of the bread-nut, and by layers, root-cuttings, or suckers in the case of the bread-fruit.

LITCHI or LITCHEE (*Nephelium Litchi*), a small tree native of China, cultivated in India, where it is said to thrive up to about 3,000 feet, in Ceylon, Hawaii, Mauritius, &c.; introduced into Jamaica and other West Indian Islands, California, Florida and Brazil. May be propagated by seed—which soon loses its vitality—budding or grafting. The pulp surrounding the seed is often eaten in a fresh state, but it is very commonly dried and preserved for export from China to Europe and America.

JUJUBE or CHINESE DATE (*Zizyphus Jujuba*), a small, thorny tree, cultivated in China, India, Africa, Ceylon,

&c. The fruit preserved is an important food in China and other Eastern countries ; dried fruits are often sold in the local markets and sometimes come into the London market. The tree is easily propagated by seed ; grows freely and quickly in comparatively poor soil, but responds to good

BREAD-FRUIT (*Artocarpus incisa*).
[*From "Manual of Tropical and Sub-tropical Fruits," by W. Popenoe.*

cultivation. It thrives in dry, arid regions, and the thorny branches make it of value as a hedge plant.

DURIAN (*Durio Zibethinus*), a large tree native of Malaya, where the fruit is famous as being at once the most objectionable—in the prickly pericarp and offensive odour—and the most delectable—in the pulp surrounding the seed, when the taste has been acquired. The seeds are roasted and

THE LITCHI, FAVOURITE FRUIT OF THE CHINESE.

[*From "Manual of Tropical and Sub-tropical Fruits," by W. Popenoe.*

eaten like chestnuts. Propagated by seeds, which should be sown early, as they soon lose their vitality, and requires good cultivation in a deep, rich soil. The tree, although planted experimentally in several tropical countries, does not appear to have spread much beyond the eastern tropics.

The MANGOSTEEN (*Garcinia Mangostana*) is another famous fruit of Malaya, following the foregoing closely in popularity. It has been grown to perfection in Trinidad and Dominica: cultivated in Ceylon and, although there is a good trade in the fruits, from Singapore to Calcutta, and locally where grown, it is on rare occasions only that a few fruits have found their way into this country. This may be owing to the slow growth—one to two years before being large enough to plant out, and eight to ten years to come to maturity. Plants may be raised from seed—which does not retain its vitality for long—in nursery beds or bamboo pots; planted out about the age mentioned above, at distances of about 20 feet. A rich, deep, loamy soil and a good rainfall are indispensable to satisfactory growth.

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CHAPTER VIII

SPICES

THE NUTMEG. *Myristica fragrans.*

Habitat.

THE nutmeg tree is a native of the Molucca Islands, and it is largely cultivated there and in many of the other islands of the Eastern Archipelago. The Moluccas, or spice islands as they are sometimes called, were taken possession of in 1619 by the Dutch, who encouraged the cultivation of nutmegs and cloves in some of the islands, whilst they used every means in their power to create a monopoly in the spice trade. Only a certain number of nutmeg and clove trees were allowed to grow, all others being ruthlessly destroyed. When the crops were too abundant, immense quantities of spices were actually burned so as to keep up the high prices in the markets. Although enormous profits were made in this way by the Dutch, they kept the natives who raised the spices in a condition of abject poverty, and so great did the oppression bear on the poor people that the natives of the island became nearly extinct. Fortunately, this disgraceful monopoly was broken down; clove trees were found growing on some of the islands not taken possession of by the Dutch, and the French carried plants to Mauritius and from thence to Cayenne. And it is recorded that the nutmegs were sown, in other islands, by a species of pigeon, and in this way plants sprang up and became disseminated.

The Dutch spice monopoly.

How the cultivation was extended to other countries.

The nutmeg tree which grows to a height of from thirty to fifty feet, bears a fruit which resembles the apricot of temperate climates. The fruit, when ripe, bursts into two pieces and discloses, inside, a dark nut covered with a brilliant scarlet reticulated covering called an aril—and this is the *mace* of commerce. The tree is diœcious—that is, the male flowers are borne on one tree and the female on another ; Description of the tree. The fruit. The flowers.

NUTMEG. *Myristica fragrans.*

1.—Flower. 2.—Nutmeg with mace.

pollination, therefore, can only be effected by the agency of winds and insects.

Soil.—The best soil for the nutmeg tree is an alluvium formed of a deep, friable loam, with good drainage. The plant will not thrive on sandy soils, and stagnant water about the roots will soon kill it. Virgin forest land, with a soil of red loam covered with a layer of humus, is well adapted to The best soil. Forest land

the cultivation, and in such a situation, if the climate be suitable, the trees will bear large crops.

A hot and moist climate necessary.

CLIMATE.—A hot, moist climate is requisite, and the trees must be sheltered from high winds, which would blow off the flowers, and shake the trees too much—for the roots take a slender hold of the ground. The rainfall should be at least sixty or seventy inches per annum; and, as the nutmeg is essentially a lowland plant, its cultivation is not likely to prove successful at a higher elevation than 1,500 feet above the sea.

Seed.

PROPAGATION.—Plants are raised from fresh seed, which may be sown in nursery beds, in bamboos, or "at stake" in

Nurseries.

the fields. The nursery beds having been made in a place sheltered from the sun and from winds, large, ripe, round nuts, quite fresh, are selected and planted a foot apart at the distance of about an inch below the surface of the soil. The nurseries must be watered every day in dry weather, and then the seedlings will appear in from thirty to sixty days. When

Transplanting.

the plants are about two or three feet high, they may be transplanted to their permanent situations during wet weather. If the seed be planted in bamboos, great care must be taken that the earth does not become dry; for if this occur, ger-

Fresh seed necessary.

mination will not take place. And, furthermore, the nuts will not germinate if they become so dry as to rattle in the shell when they are shaken. A Grenada planter, who has much experience in nutmeg cultivation, recommends the seed should be planted in the place where the tree is to grow, as the plants then come on much faster and fruit earlier. A drawback to this system is that the land is occupied with plants, many of them possibly staminate, and therefore useless and the expenses of cultivation are greatly increased.

Distances.

CULTIVATION.—The distances at which the plants are set out should be from twenty-five to thirty feet, the wider space

being adopted on rich level lands. Holes are then dug and left open for a time, and filled in with surface soil, rubbish, and cow-dung mixed with burnt earth; but if the land be very rich, the manure may be dispensed with. After the young trees are planted out, they must be shaded; and in dry weather, they should be well watered every week at least. Bananas will answer well for shade, and they will give good returns until they have to be cut down to make room for the growing nutmeg trees. The land will require constant weeding, and care must be taken not to injure the roots, which often break through the surface. When the trees are backward in growth they should be manured with farm-yard compost or good leaf mould. The ground is carefully loosened all over under the trees, so as not to injure the roots, and then the manure is lightly spread or scattered around the trees close to the stem, and allowed to work its way into the soil. It will not do to dig holes for the manure, as the roots would be injured, and this often results in the death of the trees. When the roots are uncovered, as often happens on sloping land owing to the wash of heavy rains, they must be moulded up. Should dry weather come on, the ground around the stem of the trees may be "mulched," that is covered up with straw, or leaves or stable litter. All parasitic and epiphytic plants, which attach themselves to the stem and branches of the trees, should be removed at once, for otherwise they will have a most injurious effect. The pruning operations are simple. All suckers must be cut away with a sharp knife, and the lower branches should be removed gradually until there is sufficient space for working under the trees.

Shade.

Bananas.

Manuring

The roots not to be injured.

Mulching

Pruning.

When the trees flower, the sexes must be determined, so as to ascertain whether there is a larger proportion of female trees. One male to every eight or ten females is quite enough; and those male trees should be, if possible, on the windward side of the plantation, so that the pollen may be carried by the wind to the pistils.

Male and female trees.

How to determine the sexes.

The sexes of the trees can only be made out with certainty when the flowers appear. The staminate flowers are from three to five, or more on a peduncle, and the pistillate flowers are often solitary. Both kinds of flowers are small, of a yellowish colour, and the perianth is bell-shaped with three or four teeth at the top.

The male flowers

On cutting open the flower longitudinally, with a sharp penknife, the sex may be determined. The anthers are set around the top of a central column; and, if the flower be

FIG. 1.

FIG. 2.

MALE AND FEMALE FLOWERS OF THE NUTMEG.

FIG. 1.—Staminate or male flower, with half of the perianth removed to show the stamens.

FIG. 2.—Pistillate or female flower, with half of the perianth removed to show the pistil.

The female flowers.

fully open, the yellow pollen may be easily seen. In the pistillate flowers, it will be noticed that the pistil is shorter than the perianth, that it is swollen at the base, and crowned with the stigma—which is indistinctly cut into two lobes.

Male plants occur more numerously than female ones, a writer on the subject stating that this excess is from ten to fifteen per cent. This estimate may, in some circumstances, be too low, for in exceptional instances as many as seventy-five per cent. have proved to be males. Should there be too many males on the plantation they may be headed down, and grafted with scions taken from female trees. Mr. P. F. Higgins, of St. Vincent, has grafted nutmegs in this manner;

Grafting the males.

NUTMEG TREE.
[From "Spices," by Henry N. Ridley.

NUTMEG (*Myristica fragrans*, Houtt) (Myristicaceæ).

A, anther-column. B, vertical section of ovary. C, anther. D, open female flower. E, fruit. F, section of fruit. G, seed. H, same, transverse. I, embryo.

but this method, though quite practicable, does not appear to have become general. A good plan is to plant two trees in each hole—at a distance of two feet from each other, and when the flowers appear it will rarely happen that both trees will turn out to be males. The male can then be cut out and the female left.

Trees bear at the seventh year.

CROPS. When grown under favourable conditions the nutmeg tree will commence to bear at the seventh year or earlier, and the produce will go on increasing up to the fifteenth year, when a full crop may be expected. In the East, there are usually three crops a year, and the ripe nut takes a little over six months to grow from the flower. The fruit is picked up every morning after it has fallen to the ground, or, if the trees are not too high it is gathered by means of a hook attached to a long stick; the mace is then stripped off and the nuts are dried in sheds, in wickerwork trays, raised about ten feet above the earthen floor on which smouldering fires are kept up all night and put out during the day time. The heat should not be more than 140 Fahrenheit. The nuts are turned in the trays occasionally; and, when they are thoroughly dry, the shells are broken with wooden mallets, and the nuts are rubbed over with sifted dry lime to prevent worms attacking them, and then packed in tight casks for export. It is well to smoke the inside of the packages and then to white-wash them. If boxes are used for shipping the nutmegs, the seams must be stopped up, for every precaution is to be taken to prevent the nuts from becoming worm-eaten. In the West Indies, the nutmegs are usually dried in the sun, but they then become more shrivelled and lose some of their value.

Gathering the nuts.

Drying the nuts.

Liming the nuts.

Packing.

Returns.

With proper cultivation, a return of from 1,500 to 2,000 nuts should be obtained from each tree in full bearing, and, in some cases, as many as 20,000 have been gathered from single trees. When the produce reaches the home markets it is *garbled*, that is the nuts are sorted according to their

Garbling.

size and the worm-pricked ones are thrown aside. Large fine, round nuts are worth double the price of small ones, and so in planting the seed the largest and roundest nuts must be selected.

Market grades.

There are usually three grades in the market, according to the number of nuts that go to the pound. These grades are as follows :—

Large	. .	60 to 80 nuts to the lb.
Medium	. .	85 to 95 „ „ „ „
Small	. .	100 to 125 „ „ „ „

Drying the mace.

MACE.—The scarlet aril of the nutmeg is stripped off as soon as the fruit is gathered, flattened by the hand, and placed on mats, or in trays, to dry in the sun for three or four days. It then turns to a yellowish-brown colour and

Packing.

becomes the mace of commerce. Mace is usually shipped in

Returns.

bales or in bags, and it should be packed tightly to prevent it becoming broken. The yield of mace is about a fifth in weight of that of the nutmegs, so that if a tree give a crop of 1,800 fruits, the net return would be about 20 lbs. of nutmegs and 5 lbs. of mace.

THE CLOVE. *Eugenia caryophyllata.*

Habitat.

THE clove, like the nutmeg tree, is a native of the Moluccas or spice islands. The Dutch, as we have seen, endeavoured

The Dutch monopoly.

to monopolise the trade in these spices ; and, to that end they restricted the cultivation of the clove to the small island of Amboyna, and made every effort to extirpate the plant elsewhere. But the French succeeded in carrying living

Introduction of the clove into Dominica and other West Indian Islands.

plants to Cayenne, and from thence it was brought in the year 1789 to Dominica by a M. Buée, who successfully cultivated the clove and other spices only to be ruined in the end, by the operation of the duties imposed on West Indian spices in England, through the jealousy of influential persons

who were interested in the trade of the East. More than a hundred years have elapsed since the unfortunate M. Buée introduced the spices into Dominica; one of the clove trees planted by him is still alive and flourishing, and the cinnamon bushes have become almost wild, as the seeds are disseminated by birds. From Dominica, the clove tree was carried to Martinique, and to other islands of the West Indies.

Description of the clove.

Cloves are the dried unexpanded flowers of the tree. The corolla forms a ball on the top of the bud between the four teeth of the calyx—from which the ovary tapers downwards. Thus the spice has somewhat the appearance of a nail, and, indeed, the name *clove* is derived from the French word *clou*, which means a nail. From nine to fifteen flower-buds come out at the end of a branch to which they are jointed, and thus they are easily detached when the trees are beaten lightly with reeds or sticks. The buds are at first green, and, as they mature, they become pale yellow and then bright red—at which stage they are ready to gather. If the buds be left on the tree, a certain number of flowers will become fertilised, the ovaries covered with the lower part of the calyx then swell and form the fruit, which is a large ovoid purple berry, containing one or two seeds, and known as the "mother clove."

When cloves should be gathered.

The best soil.

SOIL.—A clayey loam is the best soil for the cultivation of the clove, provided the land be well drained. The trees grow well on sloping land, as in such situations stagnant moisture cannot exist. The plant does not thrive in clays or sands, and a marshy soil is fatal to it.

A marine climate to be avoided.

CLIMATE.—Although the clove is a native of the small islands of the Moluccas it will not grow quite close to the sea, or in places where the atmosphere is laden with saline particles carried inland by strong sea breezes. Nor will the tree thrive in the mountains, although it will do well on the slopes below 1,000 feet elevation. The tree must

be planted in sheltered situations, for high overhanging shade is inimical to its growth.

Layering.

Nurseries.

Fresh seed necessary.

Transplanting.

PROPAGATION.—Plants may be raised from seed, or by layering. If the young branches are laid down and kept moist, they will take root in about six months. The nursery beds, made in a sheltered situation with rich mould, should be sown with the seeds at distances of about a foot from each other. Fresh seed must be planted, as it soon loses its vitality; and, as germination takes place within a few weeks, the seed must be sown not more than two inches below the surface. The seedlings require frequent waterings in dry weather, and they should not be transplanted until they are three or four feet high. The plan so successfully adopted at the end of the last century by M. Buée, on his plantation in Dominica, is so admirable that it may with advantage be transcribed here from the account in Porter's "Tropical Agriculturist," published in 1833. "The "seeds were sown at about six inches[1] apart from each other "in beds. Over these beds small frames were erected about "three feet from the ground, and plantain-leaves were spread "on the top in order to shelter the young plants from the "sun. The leaves were allowed gradually to decay and, at "the end of nine months, the young plants, which by that "time were strong, were allowed to receive the benefit of the "sun; but if not protected from it when very young, they "were found to droop and die."

Shelter sheds.

Shade required.

CULTIVATION.—The land must be lined at twenty feet distances, and holes dug as described in the case of the nutmeg. The seedlings are transplanted at the beginning of the rainy season, and shade is necessary for the first two or three years by which time the plants are strong enough to bear the sun. At the sixth year the young trees will commence to bear, and the crops will go on increasing year by year until the full height of thirty feet or more is reached. In the Moluccas

[1] This is too close: a better distance is twelve inches.

CLOVE TREE.

[*From "Spices," by H. N. Ridley.*

BRANCH OF CLOVE.
With the cloves ripe for gathering.
[*From "Spices," by H. N. Ridley.*

the trees are topped at 8 or 9 feet for the facility of gathering the crops, but this plan appears to decrease the yield considerably. The general cultivation is the same as that described for the nutmegs; but the clove is a hardier tree than the nutmeg, and it does not, therefore, require such careful attention. Topping the trees. The clove hardier than the nutmeg.

CROPS.—When the flower-buds begin to grow red the reaping operations must begin. The nearest clusters may be taken off with the hand, but the more distant ones are to be pulled off with crooked sticks, or beaten off gently with bamboos. The trees must not be rudely handled, lest the next year's crop be diminished by the injury to the branches. The ground underneath the trees must be swept clean, or cloths may be spread so as to catch the cloves as they are knocked or pulled off from the branches. How to gather the crops.

The yield varies year by year. Usually, at intervals of from three to six years very heavy crops are borne by the trees, but now and then a year comes when they do not bear at all. On an average, it is said, five pounds of dried cloves may be expected from each tree; but, in Dominica, trees have been known to give more than ten times this quantity. Returns. Large crops in Dominica.

In the East Indies the cloves are cured by being smoked on hurdles, covered with matting, over a slow wood fire until they become of a deep brown colour, when they are further dried in the sun. Sometimes the buds are scalded with hot water before being smoked, but this is an unnecessary process. The fires, however, may be dispensed with, for by simply drying the buds in the sun, they may be properly cured. The crop loses 60 per cent. of its weight by drying. When cured, the cloves may be packed in bags or in barrels for export, and care must be taken that the packages are kept dry to prevent subsequent deterioration. Smoking the cloves. Drying in the sun. Packing.

The chief commercial sources are Zanzibar and Pemba; prices (1926) from 8½*d.* to 9½*d.* per lb. Upwards of 4½ million pounds are imported from these islands out of an approximate total of 8½ millions from all sources annually. Chief commercial sources.

PIMENTO. *Pimenta officinalis.*

Habitat.

PIMENTO is the dried, unripe fruit of a tree which grows wild in Jamaica, Dominica and other parts of the West Indies, as well as in Central and South America. Jamaica is the chief source of this spice, the annual production being calculated at from 50,000 to 60,000 bags of 150 lbs. each; average price 12*s.* to 24*s.* per 100 lbs. Pimento, or Jamaica pepper as it is sometimes called, is round, of the size of a small pea, of a dark colour, with the remains of the calyx attached, and it possesses an agreeable odour and flavour, supposed to resemble a combination of those of cinnamon, cloves and nutmegs, and hence the name *allspice,* under which it is commonly known in domestic use.

Exports from Jamaica.

Description of the spice.

The tree.

The tree is a very handsome one, reaching to a height of 30 feet, and possessing, usually, a single, smooth, clean stem with a light ashen or brown-coloured bark, which peels off in thin flakes as the trunk increases in size.

Thrives on poor soils.

SOIL AND CLIMATE.—Pimento is the only one of the spices which grows on a poor soil, indeed one writer goes so far as to say that it thrives on barren land. The soil must be of a friable nature and well drained, such as is found along the rocky or stony slopes of the sea-board of some of the more mountainous of the West Indian islands. The tree does not do well in clay or sandy soils, and it will not grow in marshy situations. The best climate is a hot and dry one, and exposure to wind does no particular harm.

Climate.

How the plantations are established in Jamaica.

FORMATION OF A PIMENTO WALK.—The system of propagation and planting out, adopted in the case of most other cultivations, is not employed in the formation of a pimento "walk"—as the plantation is usually called in Jamaica. Mr. Morris thus describes the peculiarly easy way in which a pimento plantation is established. "In Jamaica the usual system of establishing a pimento walk is to allow a piece

PIMENTO: BOTANICAL FIGURE SHOWING BERRIES.

[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

of land in the neighbourhood of already existing pimento trees to become overgrown with bush, which, in the course of time, is found to contain numerous pimento seedlings, grown from seeds devoured by birds and deposited there. When the plants are of a certain size, the bush is cleared, and the pimento trees allowed to grow up." In places where the trees are too close together, the surplus ones must be removed, and some of them may be planted in situations where vacancies occur. In order to ensure good crops the trees should not be allowed to grow closer than twenty or twenty-five feet from each other.

Thinning out the trees.

Distances.

Returns.

CROPS.—In about seven years small crops may be gathered; and, until the trees attain their full height and spread, the crops will usually increase year by year. The green berries are collected, soon after the blossom falls, in the following manner: Persons climb the trees and break off the young branches, with the fruit attached, which are thrown down to women and children under the trees who pick off the berries from the stalks and carry them to the drying places. The man up in the tree can usually keep three persons fully at work below. Care must be taken to separate, as far as possible, all ripe berries from the green ones, for otherwise the produce will be deteriorated.

Gathering the spice.

Ripe berries to be separated.

Drying the spice.

The green berries brought in by the women and children are dried in the sun in the same manner as is coffee, on barbecues or in trays, the drying process varying from three to twelve days. In wet weather the system employed in smoking cloves may be adapted to the drying of pimento, or an American fruit evaporator can be used. The proper degree of dryness is ascertained by the wrinkled appearance, the dark colour of the spice and the rattling noise made by the seeds when they are shaken. The spice is then packed in bags or in casks for shipment.

Crops.

The returns from the plantation depend on the seasons and the state of the markets. Sometimes the crops are

very large—a hundredweight of dried spice having been got from a single tree, at other times the produce is very small. In drying, the berries lose a third of their weight. There is not an increasing demand for pimento and during some years the prices are so low that it is found not worth while to harvest the crop.

BAY LEAVES.—From the leaves of the pimento, and an allied plant, called botanically *Pimenta acris*, an essential oil is distilled, which, added to rum, makes the well-known Bay rum used so extensively in America. In Dominica, although the spice is not gathered, the leaves of *Pimenta officinalis*, and *P. acris*, are a considerable article of export to the United States, and bay oil is also distilled in the Island. The leaves are gathered and dried on the floors of houses or in large sheds, in which are erected platforms—one a few feet above the other—of wattles. The air easily passes through and around these platforms, and the leaves become dry in a few days. They are then packed in bales weighing from 200 to 250 lbs. each, and shipped to the American ports, where they fetch a good price.

Bay rum.

The bay leaf industry of Dominica.

Baling.

CINNAMON. *Cinnamomum zeylanicum.*

CINNAMON is the prepared bark of the young stems of a tree which grows wild in Ceylon, some parts of India, Cochin China, and many of the islands of the Malayan Archipelago. Most of the cinnamon of commerce, however, comes, and has always come from Ceylon, where the Portuguese and afterwards the Dutch, in the seventeenth century, succeeded in making the trade a monopoly. All the operations of the trade were carried out by government officers, and so cruel and oppressive were the laws on the subject that the selling or giving away of even a single stick of cinnamon were made a crime punishable with death. After the English captured Ceylon, in 1796, from its Dutch masters, all these barbarous

Habitat.

The Dutch monopoly.

Oppressive laws,

done away with by the English.

restrictions on the trade were done away with, but the East India Company kept up the monopoly until the year 1832 when the cinnamon trade became free to all. The tree, when left to itself, grows to a height of thirty feet with a straight stem; and, in general appearance, it is not unlike an orange tree. But, in cultivation, the tree is cut down to the ground at about the sixth year, when straight shoots spring up to be again cut down two years afterwards, so that the plant becomes really a coppiced bush, and in process of time the stools attain to a great size. The whole of the tree is useful for some purpose. The bark as a spice is the principal use, and it yields by distillation cinnamon oil; a fragrant wax is obtained from the ripe fruits by boiling them in water, and a volatile oil may be distilled from the refuse bark, leaves, fruit, young shoots and root bark.

Description of tree.

Coppicing.

The uses of the tree.

The plant a hardy one.

SOIL AND CLIMATE.—The cinnamon tree is one of the hardiest of the spices and it will grow on almost every soil and in almost any situation in the tropics, but the quality of the bark is very inferior unless the soil and surroundings are favourable to the plant. In Ceylon, the tree is often planted on worn out coffee estates, and in dry sandy soils unsuitable to most other cultivations. But a sandy loam mixed with humus is the best soil, and sheltered situations up to 1,500 feet above the sea level are best adapted for the cultivation.

The best soil.

PROPAGATION.—Plants may be raised by cuttings, by layering, and from ripe and fresh seed. The usual way, however, of establishing a "cinnamon garden," as the plantation is generally called, is to plant the seed out in the fields at distances of six or seven feet apart. The land being lined at these distances, the ground is well broken up at the stakes, wood-ashes are mixed with the soil, and four or five of the berries are sown. To protect the seedlings from the sun branches of trees are placed over the earth where the seeds are sown, and left to rot on the ground. But if dry weather come on after germination takes place, many of the

Planting at stake.

Shade.

CINNAMON PLANTATION, CEYLON. HARVESTING—CUTTING CINNAMON STICKS.
[From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.

seedlings perish, and then it is necessary to re-sow the groun
Nurseries. It is advisable, therefore, to raise plants in nursery beds, s
that the vacancies can be supplied with young growing plant
The seeds germinate in from two to three weeks.

Weeding. CULTIVATION.—After the plants are established in the fiel
very little cultivation is required beyond keeping the groun
clear of weeds—which may advantageously be buried
Crops. trenches between the trees. By the sixth year the first shoo
can be cut, when it will usually be found that two or three
them are five or six feet high, and in a condition for peelin
Two years afterwards, the shoots that have grown up aft
the first cutting may be reaped, and from four to seven
Firing the stumps. them will give good bark. The stems are cut close to t
ground, and it is said that if a fire be kindled on the stum
so as to consume it, the roots will throw out a number
long straight stems which yield the very finest cinnamon.

HARVESTING.—The shoots are cut and the tops removed
that they are left from three to five feet long, they are th
tied into bundles and carried to a shed for the preparatio
Preparing bark. of the bark. The leaves and side branches are cleared fro
the stems, and then two longitudinal slits are made with
sharp knife, one on each side of the shoot. When the cu
ting has taken place in rainy weather the bark is loose—
the sap is in free circulation—and it comes off easily, but
Rubbing the sticks. is usually necessary to rub the sticks strongly with the hand
of the peeling knife, or with a piece of smooth hard woo
six inches long and an inch in diameter. This rubbing pr
cess disengages the bark, which is then removed from ea
side in entire slips. The pieces of bark, after an hour
so, are put one within the other, collected into bundles, a
Ferment- ing. pressed and bound together. The bundles of bark are th
left for a day, or even longer, until slight fermentation s
up, which loosens the epidermis or outer skin of the ba
and thus allows its easy removal in the following manner:
The inside of the bark is applied to a fixed piece of round

CINNAMON—PEELING STEMS, CEYLON.

[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

Scraping off the epidermis.

wood, and the whole of the epidermis, and the pulpy matter underneath it, is carefully scraped off with a curved knife. The knives sold for the purpose of reaping cocoa pods answer for this purpose very well. After the epidermis is removed the bark is put one in the other, cut in lengths of about 12 inches or a little more, and placed on wicker work platforms

Drying

in the shed until the second day when the drying is finished in the sun. As the bark dries, it contracts and acquires the appearance of a quill—which is the name sometimes applied

Baling.

to it. When the spice is perfectly dry, it is made up into bundles of about 30 lbs. each, and three bundles are made into a small bale which weighs between 90 and 100 lbs. The bark of the bigger and coarser shoots cannot be quilled,

Cinnamon chips.

so it is removed in thick pieces ; and when mixed with the bark of the prunings, and of those sticks that do not peel well, is known as *chips*, which fetch a low price in the markets. Chips have not such a delicate flavour as quilled cinnamon ; but what is wanting in delicacy is made up in pungency, and, therefore, for some purposes this inferior

Returns per acre.

spice is preferred. In Ceylon, it is reckoned that the yield per acre is 150 lbs. of prepared cinnamon, but on good soil and with careful tillage and judicious manuring, larger returns ought to be obtained.

OIL.—Cinnamon oil is made by distillation from the bark unfit for shipment, and from the leaves and other parts of

Light and heavy oil.

the plant. It varies much in character, some being light, and some so heavy as to sink in water. The oil does not exist in the bark in a large proportion, for 80 lbs. of bark will yield only 6½ ozs. of heavy oil and 2½ ozs. of light oil. Further information on this subject is given under Essential Oils, p. 614.

The trade in this spice seems to have fallen off considerably of recent years and, indeed, on some plantations the plants have been rooted out in favour of rubber and coco-nuts.

CHAPTER IX

SPICES *continued*

GINGER. *Zingiber officinale.*

GINGER is the dried, underground stem of a plant which grows wild in South East Asia and some of the islands of the Malayan Archipelago, but it is cultivated extensively in South America and the West Indies, and more especially in Jamaica. The underground stems, which have the appearance of tuberous roots, are botanically called *rhizomes*, and they are known in commerce as *races*. The real roots of the ginger plant are the fibres which are given off from the rhizomes. From the underground stems, aerial, leafy shoots rise up above the ground to the height usually of from twelve to eighteen inches; but, under favourable conditions of soil and climate, they may attain to a height of three feet. The flowers are borne on a separate stalk to the leaves, and the flower spikes are commonly about a foot high.

Habitat.

Description of the plant.

SOIL AND CLIMATE.—In order to cultivate ginger with success, none but the richest and best soils should be chosen. The plant will not thrive on sands and clays or in a dry soil. A rich, vegetable loam is suitable to the cultivation, and the soil must be well drained, for otherwise the rhizomes will rot. The plant endures a wide range of climate in the tropics, for it may be grown from the sea level to high mountainous regions provided the rainfall be abundant, or irrigation be adopted. In the Himalaya mountains, lying to the

A rich soil necessary.

Climate.

GINGER PLANTS, JAMAICA.

From a Collection Royal Botanic Gardens, Kew, by permission of the Director.

GINGER DRYING, JAMAICA.

[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

CARDAMOM (*Elettaria Cardamomum*).

1, Portion of a flowering branch. 2, A flower. 3–6, Parts of the flower. 7, Transverse section of ovary. 8, Base of stem with a fruit-bearing branch. 9, Transverse section of fruit. 10–11, Seeds. 12, Section of seed. 13, A leaf. 1 and 3–6 reduced; 2, 7, 9, 11, 12 enlarged.

[*From "Medicinal Plants," by Drs. Bentley and Trimen.*

north of India, ginger is cultivated up to 5,000 feet above the sea level.

PROPAGATION.—The plant is propagated entirely by division of the rhizomes, and the cuttings are set out at once in the fields, no preparation of plants in nursery beds being at all necessary. A rhizome, or "race," is carefully divided into small pieces, care being taken to leave at least one shoot bud on the cutting, and each piece is then planted in the hole that has been specially prepared for it. Cuttings.

CULTIVATION.—The land should be well cleaned and trenched, all weeds and rubbish being buried in the trenches so as to enrich the soil. When possible, deep ploughing may be advantageously employed some time before March or April—which are the best months for planting. The cultivation is very like that of the potato. The soil is raised in ridges three or four feet apart, and small holes are opened at distances of twelve inches in the ridges. The holes are filled with well-rotted manure, and the cuttings of the rhizomes are planted in the holes at a depth of about three inches. When possible, a thick layer of leaves should be placed over the holes, so as to keep the cuttings cool and moist, besides which, when the leaves rot, they will give extra nourishment to the young, growing plants. The land must be kept weeded; and, as ginger is a very exhausting crop, manure should be dug into the land if the cultivation be kept up for successive years in the same fields. Trenching. Ridges. Weeding.

CROPS.—The cuttings having been set in March or April, the plants will flower about September, and afterwards the shoots will wither, and the rhizomes will increase in weight and size. By January or February the spice will be ready to gather, the process being simply to fork the plant out of the soil, care being taken not to injure the races, or "hands" as they are called in Jamaica. The hands, of course, vary Crops gathered in ten months.

in size according to the soil, climate, and care in cultivation, but sometimes they are very large and weigh considerably over half a pound.

Preparation of the ginger.

The hands, having been raised from the ground, are divested of the fibrous roots and cleared of all adhering mould and dirt. They are then plunged for some minutes in boiling water so as to destroy their vitality, and afterwards dried in the sun—when they become the ginger of commerce.

Scraping.

Another method of preparation is as follows:—the larger and better hands, instead of being scalded, are carefully scraped with a knife until the whole of the dark outer skin is removed, and then they are dried in the sun. The produce prepared in this way is known by the names of "scraped," "uncoated," and "white" ginger, in contra-distinction to the "unscraped," "coated," and "black" ginger—which are the terms applied to the spice prepared by scalding and drying. The darker kinds are sometimes improved in appearance by bleaching, which is effected by exposing the spice to the fumes of chloride of lime or burning sulphur. The returns from an acre of land vary considerably; but, when cultivated under favourable conditions, the crops ought to be 4,000lbs. and upwards. Ginger may be shipped in barrels or bags, the bags commonly used holding about a hundredweight of the spice.

The two kinds of ginger.

Bleaching.

Returns.

CARDAMOMS. *Elettaria Cardamomum.*

Habitat.

CARDAMOMS are the produce of a ginger-like plant growing wild in the moist mountain forests of Southern India, Ceylon and Java. Unlike ginger, however, the part of the plant yielding the spice, is the fruit, which consists of triangular, three-celled and three-valved leathery capsules, of a yellowish straw colour, enclosing many angular seeds—which have an aromatic odour and a pungent, spicy flavour. Up to now all the cardamoms of commerce come from the East Indies,

Description of the spice.

but the plant thrives well in certain situations in the West Indies, especially in Jamaica, where it was introduced on a large scale by Morris in 1881, though so far no appreciable developments would appear to have been made.

SOIL AND CLIMATE.—The best soil is a rich and moist loam with a good proportion of humus, such as is found by the banks of streams in the mountain forests of the tropics. Dry hillsides are unsuited to the cultivation, and the plants will not bear well in poor, gravelly and sandy soils, or in stiff clays. Undulating land is better than flat places, but steep inclines should, if possible, be avoided. The necessary climatic conditions may be summed up in the three words elevation, moisture and shade. Until within the last ten years, most of the cardamoms used in the world were gathered from plants growing in almost a wild condition, in the moist forests of Malabar, at elevations of from 1,800 to 3,500 feet above the sea level. The natives went into the woods, cut down the undergrowth and felled a few of the larger trees so as to let in light and air. Soon afterwards cardamom plants sprung up in all directions, and it was only necessary to thin them out where they were too thick, and to supply them where vacancies occurred. The cardamom jungle was then left alone for two years. In the third year a light weeding was done and a small crop picked. In the fourth year, the natives returned, weeded the plants thoroughly, and picked a good crop. In this cardamom region, the average mean temperature is said to be 72° F. and the rainfall about 120 inches a year. The climate of Ceylon appears to be very suitable for cultivation, and it has become one of the few important sources of production. The hot, moist climate in which pepper (*Piper nigrum*) and the betel-nut palm (*Areca Catechu*) thrive, may also be strongly recommended.

The best soil.

Climate.

Malabar cardamoms.

How grown.

Climate.

Cultivation in Ceylon.

PROPAGATION.—Plants may be raised from ripe seeds, or by division of the rhizome which is sometimes erroneously

Nurseries.

alluded to as a bulb. Nursery beds are prepared in the usual manner, and the seeds are placed in "drills" - which are drawn with the finger or scratched with a stick. The seeds germinate slowly, and may not appear above the ground until the expiration of four months. In about a year the seedlings will be a foot high, with eight or ten leaves on the shoot, and they may then be transplanted. When the plant is propagated by division, a piece of the rhizome should be carefully cut with not less than three shoots to it, and attention must be paid that the plants are injured as little as possible.

Germination slow.

Transplanting.

CULTIVATION.—A good site having been selected in forest land, all undergrowth must be cut away, as well as young trees up to 8 inches in diameter. Here and there a large tree should be felled, so as to open up the land to some of the rays of the sun. The trash may be burnt before it is quite dry, so that the burning may be as light as possible, or it may be allowed to rot on the ground. Holes a foot deep, and a foot and a half wide, are then to be dug at distances of 6 feet; but, in very rich soil, the holes may be 7 feet apart or even more. Surface soil is filled in, and the cuttings or seedlings are set in the holes, but they must not be planted too deep or they will rot off. As the cultivation will practically form a forest undergrowth, there will be very few weeds to eradicate, and the expense of keeping the cardamom plant clean will be small. One or two light weedings a year are all that are necessary. Care must be taken not to heap leaves and rubbish round the stem of the plants, as the flowering stalks spring from the roots and lie close to the ground. At the third year the plants will be about 4 feet high, and they will then yield a very small crop, but at the fourth year a full crop may be expected.

Jungle cultivation.

Distances.

The stems to be kept clean.

CROPS.—The fruit must not be allowed to ripen, or the capsules will split and the seeds will fall out. The proper

The unripe fruit to be gathered.

time to gather the capsules is when they are full and firm, and commencing to turn from a green to a yellow colour. The "pods," as the fruits are sometimes called, are to be cut with scissors, and a portion of the stalk must be left attached. If the pods be pulled off by the hand they may split, and thus ruin the spice. The fruit is cured by exposure to the sun, but the drying must be gradual so as to prevent the splitting of the pods. A few hours' sunning in the early mornings and in the afternoons, will be sufficient at first, and later on the exposure may be longer. When properly prepared, the spice is of a light straw colour. After the capsules are thoroughly dried, the remains of the stalks are easily rubbed off, and they are then separated from the spice by winnowing. In drying, cardamoms lose greatly in bulk, four or five bushels of green pods shrinking to about one bushel of dried produce.

Pods to be cut off the stalk.

Pods dried in the sun.

Winnowing

The returns from an acre vary greatly in different seasons. In the jungle cultivation of Mysore not more than 28lbs. are got from an acre, but in Ceylon the average is about 170lbs., although under most favourable conditions as much as 400lbs. have been obtained.

Returns.

In the home markets three kinds of cardamoms are recognised, under the curious names of "shorts," "short-longs," and "long-longs." Shorts are capsules from a quarter to half an inch long and a quarter of an inch broad, and the longest of the long-longs is about an inch in length.

The three market grades.

The cardamoms described here are those known as Malabar cardamoms. There is another sort found wild in the forests of Ceylon with longer and larger fruits. This used to come to European markets as Ceylon cardamoms, but since the extended cultivation of other cardamoms in the island this distinction has gradually become obliterated. At the present time cardamoms produced in Ceylon consist also of Malabar and Mysore sorts. The value on the London market is now about 6*s.* 6*d.* per lb.

Pepper. *Piper nigrum.*

Habitat.

Pepper, or black pepper as it is sometimes called, is the dried fruit of a vine found growing wild in the forests of

Large consumption.

Malabar and Travancore. It is one of the most important of the spices, and its consumption annually is something enormous, pepper to the value of nearly a million pounds sterling being imported every year into the United Kingdom alone. The vine is cultivated extensively in Southern India Siam, Malaya, Cochin China and the larger islands of the

Plant thrives in the West Indies.

Malayan Archipelago; and, although it grows well and bears good crops in the West Indies, planting enterprise has not yet been directed to this important industry. The early history of the pepper trade is similar to that of the other

The Dutch monopoly.

Eastern spices; the Dutch for a time succeeded in establishing a monopoly and long strove to restrict the cultivation to the island of Java.

The best soil.

Soil.—The plant is a hardy one, and it will grow in most soils, but the crops will be small on poor sandy soils and on clays. The best soil is a deep, well-drained vegetable loam such as is found along the alluvial banks of rivers in Malabar. The vine must not be planted on steep hill sides as the soil is liable to be washed away from the roots

Reclaimed swamps.

during heavy rain. Swamps that have been reclaimed by good drainage are suitable to the cultivation by reason of the large proportion of vegetable matter in the soil.

Climate.—A hot humid climate, such as is found in the sheltered valleys of Jamaica, Trinidad and Dominica, is the best for the cultivation. The rainfall should not be less than

Abundant rainfall necessary.

from 80 to 100 inches per annum, and it must be evenly

Shade.

distributed. Shade is essential: in the Straits Settlements the Chinese, who are the principal pepper growers there generally establish their pepper gardens in forest clearings.

PEPPER PLANTATION IN BORNEO. [*From "Spices," by H. N. Ridley.*

PEPPER PLANT.

[*From "Spices," by H. N. Ridley.*

PROPAGATION.—The vines may be raised by cuttings, or rom seed. The cuttings are usually eighteen inches long, nd they may be set out in the fields, or put in nursery beds ntil they have rooted. The ends of the vines make the best uttings as they have a growing terminal bud, and they should e put in the ground when the rain falls incessantly. When lants are raised from seed, nursery beds must be made, in the sual manner, in a moist and shady locality. Good selected ipe berries are soaked in water for three days, the outer skin s then removed, the seed is dried in the shade, and then own in the nurseries in drills. Frequent waterings will be ecessary, unless the weather be very rainy, until the seed- ngs have over four leaves, by which time they will be ready o be transplanted.

Cuttings.

Nurseries.

Trans- planting.

CULTIVATION.—The land having been cleared, it is lined ut seven feet by seven, and holes are dug two feet square nd fifteen inches deep. The holes are filled in with good oil, and leaf mould when it can be got, but the earth is not o be heaped up as it is better to have a depression for the lant. The next thing to be done is to put in, at the side of ne holes, the supports for the vine, which may be hard wood osts, or living trees may be utilised. The posts should be velve feet long and about eight inches square, the lower vo feet being tarred so as to prevent the wood decaying in ne ground. Tree fern stems will answer the purpose very ell, and they are likely to last until the vines are exhausted. f living supports be used it will be necessary to establish ne trees before the pepper is planted out, and they must be opped at ten feet, and kept pollarded so as to prevent too uch shading of the vines. The mango and the cashew tree ave been recommended for the purpose, but it has been ound that a species of the "bois-immortelle," (*Erythrina rallodendron*), is the best. When the cultivation is on a nall scale, the holes may be dug close to the roots of low trees ready growing on the land. The plants should be put in

Holes.

Posts.

Tree fern stems.

Live supports.

the holes as distant as possible from the supports, and t
growing end should be directed towards the posts or tree
How the cuttings are set. which the vine is to run. When cuttings are set out in t
fields, three must be put in each hole, and their rooting en
should be turned from the post and inserted six inches de
in the ground. It is as well to bury all the cuttings exce
about four inches, which should be placed against the po
The plants should now be carefully covered up with leav
Mulching the vines. or dried grass and weeds, so as to protect the roots from t
sun, and to keep the ground moist and cool. The vines w
soon begin to grow rapidly if the planting operations ha
been done in wet weather; and, when they have run up t
posts for a distance of two feet, the ends must be nipped
so as to cause lateral shoots to be developed. In some plac
when the vines have grown up the post to a height of fi
Letting down. feet, they are carefully detached from their supports a
the ends coiled up and buried in the ground. This operati
is called "letting down," and it induces more vigorous grow
and ensures larger crops. The land must be kept free fro
Manuring. weeds; and, if the plants are of slow growth, manure m
be applied to the surface of the ground over the roots.
must not be forked in, but it may be lightly covered with s
from the vicinity.

Burnt earth. The Chinese pepper growers of Singapore use burnt ear
extensively as a manure, and it appears to answer very w
for the purpose; rotten fish is also employed advantageous

When the vines bear. CROPS.—In from two and a half to three years a sm
crop may be expected, and the vines will be in full beari
by the sixth or seventh year. Good crops may be reap
for several years thereafter, and then the vines will decli
in vigour and fruitfulness. Under most favourable con
tions of soil and climate, however, the plants will go
bearing well for much longer periods, and in certain i
stances crops have been gathered up to the thirtieth ye
The fruits are small, round, and berry-like; they grow loose

to the number of 20 or 30 on a pendulous stalk, or "spike" as it is called. At first the fruit is green, then it becomes red, and finally yellow—when it is ripe. As soon as one or two of the berries commences to turn red, the whole spike is gathered and dried in the sun, the berries are then rubbed off the spike with the hand, the stalks are picked out, and the spice is winnowed to free it from dirt and foreign matters and then packed in bags for shipment. Each bag contains about 142lbs. of the spice. Gathering the crops. Winnowing.

The yield varies very much, and it may be from half a pound to seven pounds for each vine; and these figures give for plants at seven feet distances, from 443lbs. to over 6,000lbs. per acre. With good cultivation and a suitable soil 4,000lbs. an acre ought to be obtained. Returns.

WHITE PEPPER.—This is simply the black pepper deprived of its outer covering. The largest and ripest berries, after being gathered, are placed in heaps for several days in a closed place, and allowed to ferment. The heaps are then trodden down and trampled upon so as to loosen the outer skin, which is washed off, and the pepper is dried in the sun. Sometimes the berries are allowed to ripen on the vines, and they are then gathered and kept in the house for three days. After this they are washed and rubbed in a basket till all the stalks and pulp are removed. Prices per lb. on the London market are for "Black Singapore" *1s. 6d.*; "Lampong" (Sumatra) *1s. 3d.*; "White Muntok" *2s. 2d.* Fermenting. Market prices.

VANILLA. *Vanilla planifolia.*

VANILLA beans are the cured fruits of a climbing orchid found growing wild in the hot humid forests of Central and South America. When the Spaniards conquered Mexico they found vanilla in use among the Aztecs for flavouring chocolate, and it is used for the same purpose by the English and French chocolate manufacturers of the present day. The vine is now cultivated in Mexico, Brazil, Honduras, Guadeloupe, Habitat. The uses of the spice.

Réunion, Mauritius, the Seychelles, Java, and Tahiti in Polynesia, but a considerable portion of the vanilla of commerce is gathered from wild plants found growing in the forests of Mexico. In Guadeloupe, Réunion and Mauritius the plant is cultivated by small proprietors, and many of the householders in these islands make money by selling the pods grown on vines cultivated in their gardens, and on the walls of their houses.

Cultivation by small proprietors.

The best soil.

Drainage necessary.

Climate.

SOIL AND CLIMATE.—A rich vegetable soil, such as is found in the dense forests of the tropics, is the best for the vanilla. Sands are too light, and clays are either too dry in hot weather, or too wet in the rainy season. An undrained, water-logged soil will cause the roots to rot, and it is, therefore, quite unsuited to the cultivation of the orchid. The climate should be hot and moist, and sheltered situations are indispensable, but the plants must not be too much shaded or the fruits will not ripen.

Cuttings.

should be long.

PROPAGATION.—The plants are raised from cuttings, and it is not necessary to set them in nursery beds to strike root. Cuttings four or five feet long are planted at the foot of trees or other supports used for the vine to grow on; and if the weather be favourable, they will soon take root. The cuttings may be got from any part of the vine; and, in cases where it is impossible to obtain a sufficient number of long cuttings, shorter ones may be employed, but the plants will sooner come into bearing if the cuttings be the proper length.

Supports for the vine.

CULTIVATION.—The vanilla vine, as we have seen, requires a support to grow upon, and as the fertilisation of the flowers will have to be done artificially, it will be necessary for the plant to be trained so as to bring the flowers within reach of the hand. When the cultivation is carried on in gardens, stone walls, trees, or wooden trellis work can be utilised for supports; but, in cases where the plants are grown on a

larger scale, trees will have to be specially planted, or posts will have to be fixed in the ground for the vines to attach themselves to. These posts should be of some hard wood that will not rot in the earth, and to that end the lower portion may be charred and afterwards tarred. Unbarked log-wood, calabash, or tree-fern stems may be employed, and the portion out of the ground should be about five feet high. It is far better, however, that the supports should be living trees, and the best for the purpose is the Physic-nut, *Jatropha Curcas*, which may be raised from seed or grown from live posts, which, if put in the ground in rainy weather, will in most instances soon take root. Holes are dug and the supports planted, in the same way as advised in the cultivation of the pepper vine, except that the distances, at which the supports are placed, should not be more than six feet. The holes should be filled in with rich loam mixed with sand and decayed leaves, and if the plantation be in the vicinity of the forest, the rich humus found on the surface of the ground should be used in filling up the holes. The soil must be heaped up so as to prevent stagnating moisture; indeed it is better to form a bed about six inches above the level of the ground, and this bed may be prevented from washing down during the rains by encircling it with a rough wall of stones. The three lower leaves of the cuttings are removed, and that portion of the stem planted three or four inches below the surface; the remainder of the stem is then tied to the post or tree by a flat band of plantain fibre, or by a cocoa-nut leaflet. Round cord must not be used as it is liable to cut into and injure the green succulent stem of the vanilla. The ground over the buried part of the cutting is then mulched with leaves or light brushwood; and, if dry weather come on, frequent waterings will be necessary, until the vine has taken root.

Posts.

Living trees the best supports.

Holes.

Distances.

Humus.

Beds.

Setting the cuttings.

Mulching.

Watering necessary.

The ground must be kept free from weeds, and unless it be lightly shaded by the growing physic-nut trees, it will be advisable in dry weather to keep the roots constantly mulched.

Transverse supports.

When the vines have reached the tops of the trees or other supports, bamboos may be fixed horizontally from tree to tree or post to post, and the vines trained along them. The trees must be kept down low so that the vines do not get out of reach, and the branches must be judiciously lopped in order to prevent too much shade. No animal or artificial manures should be used, but rotten leaves and vegetable soil may be applied to the roots after each crop is gathered.

Manures.

Crops in the fourth year.

FERTILISATION OF THE FLOWERS.—The plants will commence to flower in the second year after planting, and full crops may be expected in the fourth year. In Central and South America, where the orchid grows wild, fertilisation of the flowers is effected by means of insects or other agency.

Artificial fertilisation essential.

The parts of the flower are so arranged that self-pollination is impossible; and, therefore, it must be effected by some foreign agency. It is usually said that this agency is an insect one, but none of the writers on the vanilla give any description of the insect or any particulars regarding it. The author of this book once gathered a few vanilla pods from vines growing in his garden in Dominica, and as none of the flowers were artificially fertilised that year it is probable that pollination was effected by humming birds, which were frequently seen to insert their long beaks into the flower for the purpose of extracting the nectar. It is likely, therefore, that birds may have as much to do with fertilisation of the vanilla orchid as insects. In the cultivation of the plant, however, it will not do to depend on such precarious agencies, and the planter, in order to ensure crops, must fertilise the plants himself.

Fertilisation by humming birds.

Description of the flowers.

The flower of the vanilla orchid is very different from the type of flower described in the first part of this book; but, on examining it carefully, the outer floral envelope, consisting of three sepals, and the inner one, consisting of three petals, may be made out. The lowest of the petals is very different from the others; it is called the *labellum*, or lip,

VANILLA.
[*From "Spices," by H. N. Ridley.*

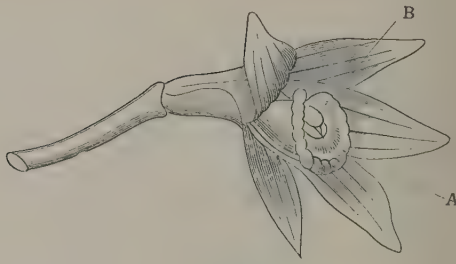

FIG. 1.

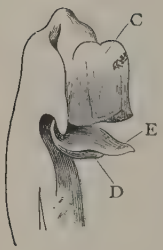

FIG. 2.

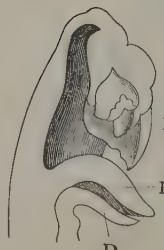

FIG. 3.

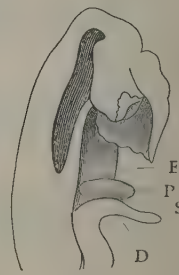

FIG. 4.

A VANILLA FLOWER TO ILLUSTRATE THE METHOD OF ARTIFICIAL FERTILISATION.

FIG. 1.—FLOWER OF VANILLA.
A. Labellum. B. End of Column.

FIG 2.—ENLARGED VIEW OF TOP OF COLUMN.
C. Anther covered with hood. D. Stigma. E. Lamellum.

FIG. 3.—ENLARGED SECTION THROUGH TOP OF COLUMN.
D. Stigma. E. Lamellum. P. Pollen masses.

FIG. 4.—ENLARGED SECTION THROUGH TOP OF COLUMN.
D. Stigma. S. Stigmatic surface. P. Pollen mass adhering to viscid stigmatic surface. E. Lamellum pushed up under the anther, which has the hood attached.

and it envelopes the columnar continuation of the axis of the plant on which are set the curious anther and stigma. This continuation is called the *column*, and it and the other parts of the flower are shown in the foregoing wood-cuts. At the top of the column is a *hood* which covers up the anther and pollen masses, and below this is the viscid stigmatic surface, protected and hidden by a projecting lip sometimes called the *lamellum*. Thus we see that the pollen is shut in by the hood, and the stigma is shut in by the lamellum, so that two obstacles prevent self-pollination. The object of artificial fertilisation is to remove these obstacles, and to permit the pollen masses to approach the stigma. This is easily effected, firstly, by detaching the hood, which is accomplished easily by touching it lightly with a piece of sharpened wood ; secondly, by slipping the lamellum under the anther ; and, thirdly, by ensuring contact of the pollen and stigma by gentle pressure between the thumb and forefinger. The operation is performed in a few seconds after a little practice, and it may be facilitated by holding the column between the thumb and middle finger of the left hand, whilst it is supported at the back with the forefinger ; the right hand is then free to use the fertilising instrument, which should be rather blunt and flattened at the end. A tooth broken from an old comb, and fixed into a piece of thin bamboo a few inches in length, has been used by the author in fertilising many vanilla flowers.

Two obstacles to self-fertilisation.

Artificial fertilisation, how accomplished.

CROPS.—If the fertilising operation prove successful, the flower will gradually wither whilst the pod will grow rapidly. If unsuccessful the flower will fall off before the second day, and the ovary will remain undeveloped, turn yellow, shrivel up, and drop off the stalk.

The flowers come out in February and March in clusters of from ten to twenty, but not more than half a dozen of the cluster should be fertilised ; and, in this way, fine large pods

The flowering season.

The hour to fertilise the flowers.

will be secured. Fertilisation should be commenced about 9 or 10 o'clock in the morning, for if it be left too late pollination may be incomplete, or fail altogether. The fruit goes on growing for a month, but it will take at least five months

Gathering the pods.

longer to ripen sufficiently for harvesting. The pods are to be gathered when they begin to turn yellow at their ends, or when they produce a crackling sensation on being pressed lightly between the fingers. Each pod should be gathered separately, by being bent to one side, when it will snap off the stem. It is very important to gather the pods at the right time, for if they be too ripe they will split open in curing; and if too green, they are dried with difficulty, and they will have little or no perfume.

The pods to be plunged into hot water.

Drying on blankets.

Straightening the pods

Binding up the split pods.

CURING.—After the beans are gathered they are plunged for half a minute in hot water that is almost boiling. They are then put on mats to drain dry, and afterwards they are spread out on blankets and exposed to the sun. Every evening they are rolled up in the blankets, and shut up in tight boxes to ferment. The sunning process is continued for a week, or until the pods become brown and pliable, when they are squeezed between the fingers to straighten them, and to cause the seeds and oily substance inside to be evenly distributed. Should any of the pods split they should be closed up and bound round tightly with silk thread or narrow tape. As they dry and shrivel the thread should be unwound and the pods tied up again. When the pods are brown, the drying process should be finished in the shade, which may take many weeks. Sometimes the beans are slightly anointed with castor or olive oil, but this cannot be recommended as the oil may become rancid, and thus spoil the product.

Sorting.

PACKING.—The dried beans are to be sorted according to their length, the long thin ones being the most valuable. Beans of the same length are to be tied in bundles of twenty-

"BIRD PEPPER," OR FRUITING BRANCH OF "CHILLIES" (*Capsicum frutescens*).

1, Branch, showing flowers and fruit. 2–4, Parts of flower (magnified). 5, Seed (natural size). 6 and 7, Seed and section (magnified).

[*From "Medicinal Plants," by Dr. Bentley and Dr. H. Trimen.*

five or fifty, the ligatures usually being applied close to each end of the bundle. The bundles are then packed in closely fitting tin boxes, which are enclosed in rough wooden cases. In Guadeloupe the bundles are put into clean kerosine oil tins, which are soldered up so as to exclude all air and moisture.

Trade.

The chief commercial sources are Seychelles, Mauritius Reunion, Bourbon, Madagascar, Fiji, Java, Ceylon, Mexico and Tahiti, to the extent of several hundred tons per year; total from all sources in 1910 being 575 tons, when Seychelles "good long" realised 14*s.* per lb. and Ceylon "fair to good medium" 13*s.* 6*d.* The French vanilla trade is perhaps of first importance, Marseilles being the principal port of entry, where in 1926 stocks of upwards of 200 tons were held at one time. The selling price on the London market (June 1926) was for Seychelles—12*s.* 6*d.* to 13*s.* 6*d.* (7 in. to 8 in.): 10*s.* 6*d.* to 11*s.* 6d. (6½ in. to 7 in.); 9*s.* to 10*s.* (5 in. to 6 in.), and 8*s.* to 8*s.* 6*d.* (4½ in. to 5 in.) per lb. Vanillins, the aromatic constituent of vanilla, is produced artificially on a commercial scale, made largely from eugenol, obtained from oil of cloves, as the raw material. The market value of this synthetic product in 1926 was approximately 22*s.* per lb.

Capsicums and Chillies. *Capsicum annuum* and *C. frutescens.*

Capsicum annuum is a small annual plant widely distributed in the tropics of the Old and New World; there are upwards of 150 varieties under cultivation, including those with small, pungent and large, mild or sweet fruits. Amongst the pungent varieties may be mentioned "Nepal," "Tabasco," &c., and of the mild, "Bell," "Sweet Mountain," "Ruby King," "Mammoth Golden Queen," "Chinese Giant," "Paprika," &c.

Varieties.

Capsicum frutescens, Linn., is a small shrub, common throughout all tropical countries. This species is the one principally used in making "Cayenne pepper"; but in

general the uses of both are very similar. The capsicums generally are used chiefly as condiments, in medicine, and some of the larger and milder fruits as a vegetable (stuffed with meat and baked) or eaten raw as a salad ; also used in mineral water manufacture and the seeds for feeding birds. Cayenne pepper.

The cultivation is easy. A light loamy soil is suitable, and the crop comes to maturity in from four to seven months from the time of sowing. Sown periodically, fruits may be kept in season nearly all the year round. A good crop would be from 4,000 to 8,000 lbs. per acre fresh, or, as the fruits lose weight considerably in drying, 1,000 to 2,000 lbs. when dry. The only preparation required is that of picking when just about to change colour and drying in the sun. Yield.

An extensive trade is done in the fruits under the names "capsicums" and "chillies," the former name being usually applied to the larger fruits (*annuum*) and the latter name to the smaller fruits (*frutescens*), or "bird peppers" as they are sometimes called. The principal sources of supply are Zanzibar, Uganda, Nyasaland, Kenya, Sierra Leone, Natal, India, Japan and the West Indies, to the extent of upwards of 100 tons a year by way of imports into the United Kingdom, or running into some thousands of tons when considering the total trade. Commercial sources.

Reference

"Spices," by H. N. Ridley. (Macmillan & Co., Ltd., London, 1912.)

CHAPTER X

TOBACCO. *Nicotiana Tabacum*

Habitat.

THE plant producing the leaves from which tobacco is prepared by a process of drying and fermentation, is a native of tropical America, where its use was discovered by Columbus in the year 1492. It is related that when Columbus and his followers landed in Cuba they found the natives accustomed to smoke tobacco leaves rolled up into something like the form now familiar to us as a cigar, and the Spanish explorers on their return to Spain introduced the "weed" into that country. It was not until nearly a century afterwards, namely in 1585, that the celebrated Sir Walter Raleigh carried the custom of smoking tobacco into England. At first it met with much opposition from kings popes, and other potentates. King James the First wrote a book against tobacco smoking, under the title of "A Counterblast to Tobacco," and Eastern princes sentenced smokers to cruel deaths. But, in spite of all this, the custom spread rapidly in every part of the civilized world, and it may now be considered to be universal. Several well-marked varieties are distinguished, from which have arisen numerous races, cultivated forms or hybrids. The best varieties are (1) var. *havanensis*, Comes, "Havana Tobacco" it includes the best of the Cuban tobaccos of the Vuelta de Abajo, Partidos and Remedios districts; those grown in Java and Sumatra, and the "seed leaf" types of Florida and other parts of the United States. (2) var. *virginica*, Comes

Tobacco introduced into England by Sir Walter Raleigh.

Its use at first forbidden.

Its use now universal

Botanical varieties.

"Virginia" tobacco, cultivated largely in the United States, including many hybrids—"Virginia Bright," "Orinoco," "Prior," "Golden Leaf," "Kentucky Yellow," &c.; and (3) var. *macrophylla*, Comes, "Large-leaved" tobacco, a source of some of the tobaccos from Cuba, Egypt, Persia, Turkey, Greece, &c.

Commercial forms.

The commercial grades are (1) CIGAR TOBACCOS—including "binders," "wrappers" and "fillers" imported from Java, Borneo, Sumatra, Havana, Mexico, Manila, Jamaica, &c. Cuban tobaccos are reported to produce standard fillers and first-class wrappers, and Sumatra is said to grow ideal wrappers only for cigars, (2) PIPE or CIGARETTE TOBACCOS—imported from Virginia, Kentucky, Maryland, Egypt, Turkey and Greece; and (3) CAVENDISH or NEGRO-HEAD—a general term for all kinds of "cake" or "plug" tobaccos, made chiefly from Virginia types, especially the darker kinds, the lighter-coloured tablets and those of finer quality being called "Honeydew." The home of the manufacture of Cavendish is Richmond, Virginia, and in the Kew Museum a very fine sample may be seen, made there in 1860.

Potash, lime and humus required in the soil.

SOIL.—The best soil for the cultivation of tobacco is a light sandy loam, rich in potash, lime and vegetable matter, for an analysis of the plant shows that lime, potash and nitrogenous compounds exist in it in large proportions. The celebrated Vuelta-abajo district of Cuba, which produces the finest tobacco in the world, possesses a soil of this description. Alluvial lands, when light and well drained, are suitable to the cultivation, but the plant will not thrive on clays and calcareous soils. As tobacco requires a very rich soil, newly opened forest land should be chosen where possible.

The soil of Cuba.

A rich soil required.

Heat and humidity essential to produce the best tobacco.

CLIMATE.—The climate of most hot countries is suited for its cultivation, provided a proper degree of humidity is assured. The plant, however, is a hardy one, and it grows well in northern latitudes in the summer time. In fact a large

TOBACCO NURSERY, UNDER SHADE (CHEESE CLOTH).
[*From "Southern Field Crops," by J. F. Duggar.*

TOBACCO FIELD WITH YOUNG PLANTS GROWING UNDER LATH SHADE.
[*From "Southern Field Crops," by J. F. Duggar.*

proportion of the tobacco of commerce is raised in t temperate States of America, and in some of the countri of Europe.

PROPAGATION.—Tobacco is raised entirely from seed, b after the first cutting, successive crops may be gathered fro rattoons. Great care is to be observed in the selection of t seed, which, in the first instance, should be obtained if po sible from Havana. Of the many varieties of the tobac plant cultivated in various parts of the world, in the We Indies, Sumatra and other tropical countries, Havana see would appear to produce the best crops. The seed shou be gathered from the finest plants with strong stems ar large leaves, and the tobacco farmer should always allow certain number of his best plants to run into flower and see The seed capsules are usually dried in the sun, and whe dry they are broken up by rubbing between the hands, afte wards the broken capsules and stalks are separated b winnowing, or a fine sieve may be used. The seeds a then kept in glass bottles properly corked up, and they w remain fresh for a long time.

Seed to be carefully selected.

Havana seed the best.

The seed capsules.

NURSERIES.—In Cuba the seed is sown in August or Se tember, and the same season may be adopted generally the West Indies. A piece of rich land in a convenient situ tion having been chosen, it is to be well hoed up and the covered with a layer of dry grass, or brush-wood, which shou be burnt as soon as weeds have sprung up, and in this wa the insects which are very destructive to the seedlings a destroyed. The land may be with advantage hoed up agai covered with rubbish and burnt as before, the ashes servi to supply plant food for the seedling tobacco. The beds m then be made four feet wide and ten in length, and rais about an inch above the general surface of the ground. order to provide light shade for the young plants, it is r commended to sow under cover of cheese-cloth as illustrate on page 320, or other convenient protection, the shade beir

Fire to be passed over the land.

The seed beds.

FIELD OF SUMATRA TOBACCO UNDER CHEESE CLOTH, SOUTH AFRICA.
[*From "Tobacco in South Africa," by H. W. Taylor.*

removable to harden off the seedlings when intended fo

Seed to be mixed with ashes.

planting out in the open. As the tobacco seeds are ver small it is advisable to mix them with wood ashes, or fin earth or slaked lime, in order to sow them evenly and no too thickly. After sowing, the seed is to be lightly rake into the soil, and if the weather be not showery, the bed

Hand weeding.

should be watered and kept moist. All weeds should be pulle up by the hand as they grow, and care must be taken tha the seedling plants are not injured by insects. In about si weeks the seedlings will be about three or four inches high and they can then be transplanted into the fields after a good shower of rain.

A fine tilth essential.

PREPARATION OF THE LAND.—The soil must be wel tilled so that the delicate roots of the young plants can easily penetrate it. To this end ploughing and cross-ploughing should be done several times, or until the weeds are rotter

Harrowing.

and the soil is loose and free. The clods of earth must be broken up by the harrow. When this cannot be done a few pieces of bamboo twelve feet long, with as many branches and leaves as possible, may be drawn on the ground by an ox or horse. The bamboo branches, in fact, answering the

The furrows.

same purpose as a harrow. The land is then ploughed into furrows six inches deep and three feet apart, and the tobacco

Distances.

seedlings are planted in the furrows at eighteen inches distance

Manures.

from each other. In newly cleared land no manure will be necessary, but in land that has been already cultivated rich farm-yard manure should be applied before the final ploughing. The Cuban planters have abandoned artificial manures although tobacco is a very exhausting crop, but lime, com-

Pigs put on the land.

post and wood ashes are used extensively, and pigs are sometimes put on the land so as to improve the soil.

PLANTING OUT.—A wet day should be selected for transferring the seedlings from the nurseries to the fields. The young plants must be taken up carefully and the earth

Trans-planting.

shaken from the roots. It is advisable to plant in the after-

noon in order that the seedlings may have the benefit of the dew and the cool night air before they are exposed to the sun. They must not be set in the ground so that the stems and lower leaves are covered up, or a certain portion of them will rot off. If dry weather come on, each plant should be watered until it is firmly rooted, and after about a week the fields must be gone over, and dead seedlings replaced.

The plants to be watered in dry weather.

Cigar-wrapper leaf is best grown under shade—as shown p. 323.

CULTIVATION.—When two or three leaves have grown after the plants have been set out in the fields, the furrows are partly closed with the hoe, the earth being drawn to the plants so as to mould them up. This operation may be performed every fortnight until the furrows are completely closed, and the soil raised somewhat around the stems of the tobacco plants; but this hoeing should not be done in very wet weather, as the soil will then be too tenacious to be satisfactorily dealt with. Not a single weed should be allowed to grow in the field, and the hoeing must be done often enough to keep the soil friable and well aired.

Moulding up the plants.

All weeds to be eradicated.

TOPPING.—In from thirty to forty days after the seedlings are planted out, the flower buds will begin to appear at the top of the plants; and, except in the case of those plants left to produce seed, the end of the stem with the flower bud is to be nipped off with the thumb and forefinger. By this operation from ten to fourteen leaves will be left, and these only should be allowed to mature. The number of leaves allowed to grow will depend on the strength of the plant, and the planter must use his own discretion in the matter.

The flowers.

The number of leaves allowed to grow.

SUCKERING.—This is the term applied to the operation of removing the buds which appear in the angles formed by the stem and the upper part of the leaf stalks. If these buds were allowed to develop they would grow into side branches and thus draw away nourishment from the principal leaves. The buds begin to spring forth in about a week after the

Why the axillary buds are nipped off.

plants have been topped, and they are easily broken off with the fingers. After a time fresh buds will appear and they must be removed also, each plant being gone over at regular intervals so as to prevent the formation of side shoots, thereby causing the whole vigour of the plant to be diverted to the leaves. *Suckering* is an incorrect term to be applied to this operation, but it is in general use amongst tobacco planters. *Disbudding* would describe the process with accuracy, and the employment of that word is, therefore, to be recommended.

Disbudding.

Larvæ.

ENEMIES OF THE TOBACCO PLANT.—The principal enemies of the plant are caterpillars, or *larvæ* as they are scientifically called, of butterflies and moths. The larvæ are usually found on the under surface of the leaves; and, unless they be sought out and destroyed, they will greatly injure the crops. Turkeys kill the larvæ in great numbers; and in the tobacco districts of the United States, flocks of these birds are kept for the purpose of destroying the "worms," as the *larvæ* are sometimes improperly called. On tobacco farms it is necessary for the "worming" to be done twice a day, for one larva, if left on a plant for twenty-four hours will commit sad havoc with the leaves. The caterpillar that does most damage is a big green one, and it is the larva of a large sphinx moth of a greyish black colour with orange spots on each side of the body. (*Sphinx quinquemaculatus*.

The turkeys kill the insects.

The larva of the sphinx moth.

Cutting.

HARVESTING.—As soon as the tobacco leaves are ripe, the plants must be cut down close to the root; and, after being allowed to wither in the sun, they are carried to the drying house where the leaves are converted into the manufactured tobacco so well known to everyone.

Two methods of cutting.

There are two methods of cutting. The first is that employed in Cuba and other places where the finest tobacco is grown. A number of sticks are cut and supported some distance above the ground by forks or by a rough frame-work. The cutters then with sharp curved knives quickly cut the

eaves from the plants in pairs, throwing the best leaves— Cutting the leaves in pairs.
he *wrappers*, on one side, and the inferior leaves—the *fillers*, on the other. The leaves are then hung close together on the sticks, each kind of leaf being kept separate, and they are allowed to remain in the sun until they wither. The withering makes the leaves tough, and prevents them being broken when they are handled. The withering process being accomplished, the sticks laden with tobacco leaves are carried to the drying house, where they are hung up, the sticks resting by their two ends on beams or bars put up to support them. Withering.

In the second system of cutting, each plant is cut close to the ground and laid on one side to wither in the sun. Then the plants are tied up in large bundles with bands about eighteen inches wide, and the bundles are carried to the drying house. Flat bands are used in order that the leaves may not be injured when they are tied up. Cutting the whole plant.

Care must be taken not to cut the leaves until they are quite ripe, or inferior tobacco will result. The leaves take almost three months to mature from the time of the germination of the seed, and they exhibit the following characteristics when they are ripe :—The surface is gummy to the touch, and if the end of a leaf be doubled up it will break off short ; the colour is a yellowish green, and spots appear in places, and the edges and the tips of the leaves usually curl downwards. Cutting should not be done on a wet day ; and, if the weather be favourable, a sufficient time in the morning must be allowed for the dew drops to dry up. If rain come on during the harvesting, all cutting must be stopped, and the leaves that have been reaped should be carried to the drying house with all speed. Leaves not to be cut before they are ripe. How to distinguish ripe leaves. Cutting to be done in dry weather.

Tobacco-House. — Some authorities give very minute details regarding the building of the drying house, but this may be left to the taste and the ingenuity of the tobacco planter, who has to remember that the structure is

The use of the house.

to protect the tobacco from sun, wind and rain, and to allow it to dry by a free circulation of air. The house may be an elaborate building, erected on stone wall and covered with a shingled roof, or it may be knocked up roughly with a thatched roof and wattled sides. It is better for the building to run north and south, and to have several doors so arranged as to permit free circulation of air. The inside of the house is to be arranged with a frame work of poles and cross rails on each side, so that the sticks laden with the drying tobacco may be hung up until desiccation is complete. The rails which are nailed horizontally on the upright poles should be one above the other at distances of about three feet, so that the tips of the tobacco leaves on the upper sticks do not touch the bases of the leaves on the lower ones.

Arrangements to be made to hang up the tobacco in the house.

CURING.—If tobacco leaves be taken off the plants and simply dried, they will become dry "weeds" but they will not be tobacco; for in order to turn the leaves into tobacco, they must be cured, and this process is one of the utmost importance, as on it depends the value of the crop. The finest leaves, raised from the finest seed, grown on the richest soil in the best climate, may be so spoiled by improper curing as to turn out a worthless product fit only for the rubbish heap. During the curing of tobacco certain important chemical changes are set up in the leaves by fermentation, whereby new compounds are formed. To two of these compounds, called *nicotine* and *nicotianine*, the peculiar odour and properties of tobacco are due; and, unless the leaves be properly cured, these substances will not be formed in their due proportions, if indeed they be formed at all. When the first method of cutting the leaves in pairs is adopted, the sticks with the leaves hanging on them are placed close together on the framework in the house so that the leaves on separate sticks touch each other, and they are left in this position for three days, and afterwards separated from each other by a distance of twelve inches in order

The great importance of proper curing.

The alkaloids of tobacco.

How the leaves are dried.

that the air may freely circulate amongst them and dry the leaves.

When, however, the whole plant is cut and brought to the house in bundles, the bundles are untied and the plants spread about the floor to allow the leaves to cool and to prevent fermentation. Afterwards two plants, or four plants if they be small ones, are tied together with string so as to enable them to be hung on sticks to dry. These sticks are similar to the ones used in carrying the leaves from the fields when they are cut in pairs, and they should be about an inch or a little more in diameter, and not too long or they will bend in the middle by the weight of the tobacco plants. In tying the plants together, a turn of the string should go below the first leaf so as to prevent it slipping as the stems dry up.

Tying up the plants

The tobacco leaves and plants must be kept hanging up until the mid-ribs are perfectly dry, which will not be until the lapse of at least thirty days, but the drying process may be hastened by putting the poles or sticks on frames in the sun for a few hours every fine day for three days. When dry, the leaves and plants are taken down, and stripped off the stems and put in heaps to ferment. A damp day should be selected for this work in order that the humidity of the air may make the leaves soft and pliant. In removing the leaves from the stalks, the wrappers must be kept apart from the fillers, as this will prevent the trouble of sorting out the different qualities after the leaves are cured. If the tobacco house be unfloored a platform must be constructed by laying boards or wattles on blocks of wood; and the leaves must be heaped together on this platform, each leaf being spread out evenly with the tips all in one direction. The heaps may be two or three feet high, and they should be covered with dry plantain leaves and a weight put on top. After the first day the heaps are to be opened and changed, so that the leaves in the centre of the first heap may be the outside ones in the second. This may be done several times so as to

The leaves are kept hanging up until they are quite dry.

The wrappers kept apart from the fillers.

The platform.

The heaps.

Fermentation.

prevent over-fermentation. After the heaps have been left for from thirty to forty days, all the heat will be gone, and the leaves will have acquired the qualities of tobacco. Then,

Tying the hands.

in damp weather, the heaps are broken up, and the leaves tied together in bundles of twenty-five or thirty; these bundles are sometimes called "hands." To make a hand properly, an unsound leaf is twisted into the form of a rope and wrapped round the upper part of the bundle, and secured tightly by tucking the end into the middle of the leaves—which are gently separated for the purpose.

Curing.

"Latakia" tobacco (attributed to var. *fruticosa*, Comes, the "narrow-leaved" or "shrubby" tobacco) is cured by smoking with the green wood of "oak" (*Quercus Robur*).

Fire-curing is also sometimes practised in certain parts, producing a dark and distinct-flavoured leaf, with the smoke of open fires—using unseasoned wood—below the hanging leaves in the tobacco barn or house.

Packing the tobacco.

The tobacco may now be packed in bales, or boxes, or hogsheads for shipment, considerable pressure being exerted so as to compress the leaves and to exclude as much air as possible. In Cuba and other places, before packing, it is

The bétan.

usual to sprinkle the hands lightly with a wash, called *bétan* and afterwards to arrange the hands in heaps, on the fermenting platform, pressed firmly together, for the space of from four to six days. The bétan is made by allowing some of the stalks to remain in water until they become rotten, which will usually be in about a week's time. Sometimes, the leaves are damped slightly with the wash before they are made into hands, and after the damping process they are put

The press.

back in the press for a few days. The *press* is the term usually applied to the platform on which the tobacco is bulked and pressed during the fermentation process, and it is as well to have the press arranged in a separate compartment of the drying house.

Baling press.

A baling press suitable for tobacco leaf is shown on page 514.

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CHAPTER XI

DRUGS

CINCHONA. *Cinchona succirubra*, *C. officinalis*, and other species

Habitat.

CINCHONA trees, from which the important drug quinine is obtained, are natives of the mountain forests of Colombia, Bolivia and Peru. The trees are mostly found in the valleys of the western slopes of the great Andean range of mountains at elevations of from 4,000 to 12,000 feet above the sea. The medicinal properties of cinchona bark were undoubtedly known to the earlier inhabitants of these regions, and the Jesuits who followed the Spanish conquerors of South America learnt its use from the natives of these countries. Its powerful curative effects in malarial fevers first became a matter of notoriety in the year 1638 when the drug was administered to the Countess of Chinchon, the wife of the Viceroy of Peru, and cured her of a fever that baffled the skill of the Spanish physicians. The Jesuits kept the nature of the drug a secret, but they carried it into Europe, where it became known as Jesuit's bark, and later on as Peruvian bark. Until within a comparatively recent period the drug was given in the form of the powdered bark, and of tinctures and extracts made from it; but now the active principles, called *alkaloids* the chief one of which is the well-known *quinine*—are used in preference to the bark, and their consumption in the world is enormous. Formerly all the

History of the drug.

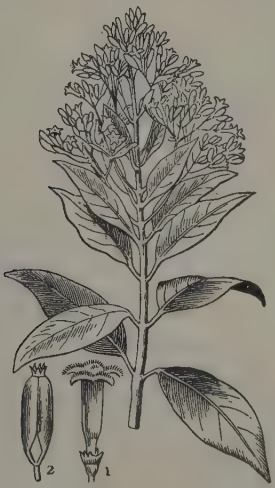
The Jesuits.

Alkaloids of the bark.

cinchona bark of commerce came from the forests of the Andes, where the bark-collectors—called *cascarilleros*—cut down the trees, removed the bark, and carried it with great labour to the ports of shipment. This was a costly proceeding, and as the trees were destroyed for their bark, the drug

The bark formerly a forest product.

The destruction of the trees.



CINCHONA (*Cinchona officinalis*).

1. Flower. 2. Fruit.

became scarcer and dearer year by year, so that it was feared the valuable medicine, in process of time, would be entirely lost. It was suggested, however, in 1839, by Dr. Royle, a distinguished Indian botanist, that an attempt should be made to cultivate the quinine tree in the mountains of the East Indies, but this suggestion was not given practical effect to until twenty years later, when the govern-

Dr. Royle.

Introduction into India and the East.

ment of India—who were expending over £12,000 a year i the purchase of quinine—commissioned Mr. (later Sir Clements Markham (1859) to collect seeds in South Americ of the true cinchona trees, which, with the co-operation o the Director of the Royal Botanic Gardens, Kew, resulted i establishing the industry, as we now understand it, on th Sikkim Himalayas and the Nilgiris of India. Dr. Anderson then in charge of the Royal Botanic Gardens, Calcutta, di much to acclimatise the plants, and Sir George King, later Director at Calcutta, developed the cultivation and th manufacture of quinine so successfully that the Governmen of India have for many years been independent of th original sources of the bark and quinine, and it is no possible for the people to obtain packets of quinine— "cinchona febrifuge" chiefly—at every post office through out India and Burma. The Dutch in Java began approxi mately at the same time, and our own Government cultivate it at the same time in Ceylon, later extending the cultivatio to Jamaica and St. Helena. The Portuguese developed small industry in St. Thomé, West Africa, and the German planted successfully in the Cameroons (West Africa) and about 1902, in Tanganyika (East Africa). At the presen time (1926), while India has successfully met the demand for local use, Java has so far made the greater commercia success of the production.

Principal species of *Cinchona*.

The chief species grown now are—(1) *Cinchona Calisaya* Wedd.—"Yellow Bark," "Calisaya Bark"; native o Bolivia; cultivated in India, Java, Ceylon and St. Thom (West Africa); a tall tree, 30 to 60 feet high, sometime shrub-like, 6 to 12 feet. (2) *C. Ledgeriana*, Moens (*C. Calisaya* var. *Ledgeriana*, Howard)—"Ledger Bark "Yellow" or "Calisaya Bark"; native of Bolivia; cultivate in India, Java and Ceylon, under experiment in Tanganyika a small tree 25 feet high and upwards. (3) *C. officinali* Linn.—"Crown Bark," "Loxa," "Pale," "Peruvian" o "Jesuit's Bark"; native of Peru; cultivated in India, Jav

and Ceylon; a tree 20 to 30 feet high. (4) *C. succirubra*, Pavon—"Red Bark"; native of Peru; cultivated in India, Java, Ceylon, St. Thomé (West Africa), Jamaica, and under experiment in Tanganyika; a tree 40 to 80 feet high.

The first three species (*Calisaya*, *Ledgeriana*, *officinalis*), more especially *Ledgeriana*, are used largely for the production of the alkaloids or active principle, and the last mentioned (*succirubra*) is more commonly used for making decoctions, febrifuges and pharmaceutical preparations, and hence known as "Druggist's Bark"; those rich in quinine sometimes being called "Factory Barks."

A rich soil necessary.

SOIL.—In the cultivation of cinchona a rich open soil is necessary, and the subsoil must be well drained, for stagnant moisture about the roots will speedily cause the death of the trees. The trees will grow better on newly cleared forest land than on grassy lands, but in all cases the subsoil should be examined to see whether it be suitable. Clays must be avoided, and so must poor sands. A rich deep vegetable loam resting on a porous gravelly sub-soil is the best for the growth of the plant, and the locality must be well sheltered from strong winds.

A mountain climate essential.

CLIMATE.—The climate must be a mountain one, for although some of the species of the *Cinchona*, and especially *C. succirubra*, grow well at low elevations, the bark yields little or no alkaloid. In Jamaica, the cinchona plantations are situated at elevations varying from 4,500 feet to 6,500 feet above the sea; the mean temperature is 63° F., and the annual rainfall average about 110 inches. Although the climate in such situations answers well for most of the cinchonas, it is not well suited for *C. succirubra*, which may be grown at elevations of from 2,000 to 4,000 feet. In general average altitudes may be somewhat misleading; but in India it has been found that *Calisaya* succeeds at 1,000 to 3,000 feet, *Ledgeriana* at 3,000 feet, *officinalis* at high elevations, upwards of 7,000 feet, and *succirubra* at 4,500 to 6,000 feet. The temperature should average about 65° F.,

Elevations at which cinchona grows in Jamaica and India.

as none of the species will stand frost, and the rainfall required should average 50–100 inches. When the forest is cleared for the establishment of a cinchona plantation broad shelter belts of trees should be left on the ridges.

CINCHONA NURSERY, MUNSONG, INDIA. PRICKING OUT SEEDLINGS.
[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

CINCHONA NURSERY, MUNSONG, INDIA. YOUNG PLANTS OF *Cinchona Ledgeriana*.
[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

Nurseries.

PROPAGATION.—Plants may be propagated by cuttings and by layering, but the best way is to raise seedlings in nursery beds, or in boxes. When shallow boxes are used they should be pierced with holes below, and the soil should rest on a layer of broken stones placed on the bottom of the box for drainage, and covered lightly with moss or sphagnum to prevent the earth washing down between the stones. The soil may be composed of leaf mould, garden earth, and fine sand in equal proportions. The seeds must be sown evenly so as almost to cover the soil, and then fine earth must be sprinkled over the seed in order to cover it lightly. The boxes must be placed in a shady and sheltered position, and kept from the rain. Frequent waterings with a very fine rose are necessary, indeed the soil should be always moist. Germination will take place in about three weeks; and, when the seedlings are two inches high, they should be transplanted to nurseries to be hardened off. When seed beds are made the soil should be well dug up and all roots and stones removed, and about two inches of a made soil similar to that used in the boxes should be laid on the beds. The beds must be under cover so as to keep off rain and sun and high winds from the young plants; a rough thatched roof erected over the beds will answer the purpose. The beds must be watered in the same way as recommended in the case of the boxes; and the young plants are to be transplanted to nurseries—also covered in with rough roofs—when they are a few inches high. As the plants increase in size and vigour the shade may be gradually removed so as to accustom the seedlings to the sun, and when they are eight or nine inches high they may be put out in their permanent places in the fields.

The soil of the nurseries.

The soil to be kept moist.

Transplanting.

The beds to be under cover.

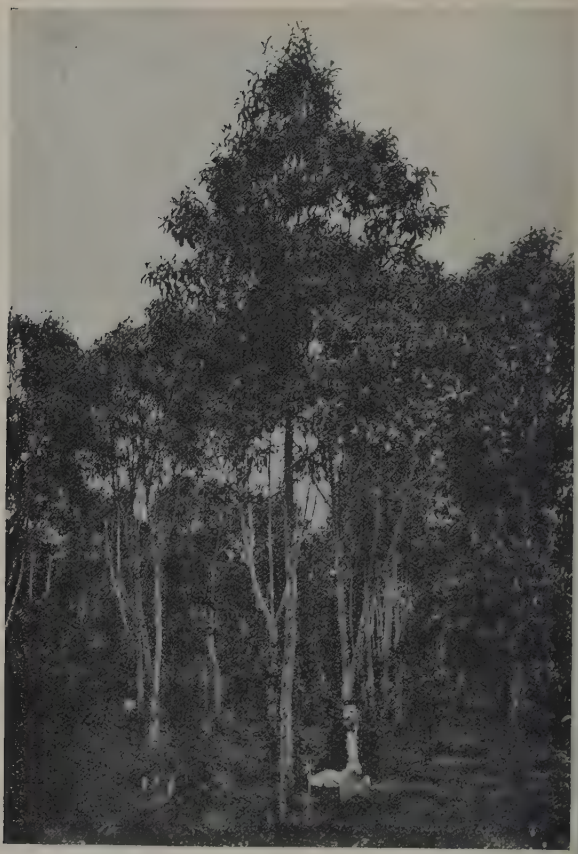
Hardening off the seedlings.

Holing the land.

CULTIVATION.—The land having been laid out, holes must be prepared for the seedling plants. These holes should be about fifteen inches deep and eighteen inches wide, roots and stones must be taken away and the same earth taken out should be put back into the holes.

CINCHONA PLANTATION (*Cinchona succirubra*), SIKKIM. TREES FOUR YEARS OLD.

[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*



TREE OF "LEDGER BARK" (*Cinchona Ledgeriana*), JAVA.
[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

The distances now usually adopted are four feet by four feet for *Cinchona succirubra*, and three feet by three for *C. officinalis*. Distances.

When the holes are filled up the young plants are put out during the rainy season, a damp, cloudy day being chosen. The roots alone should be covered with earth which is to be pressed firmly around the stem, and temporary shade may be given by fixing a small branch of a tree or a fern frond in the earth close by the seedling. Beyond keeping the plants clean and supplying vacancies, very little cultivation will be required during the first few years. The weeds should be chopped down with the cutlass, and on no account should the ground be hoed up, as the delicate superficial roots would thereby be injured or destroyed. In windy places, where the plants are two or three feet high, they may be tied to stakes driven firmly into the ground in a slanting direction, so that they touch the plants at only one part. A little dry grass may then be placed between the tree and the stake to protect the bark, and the tying must be done firmly with some flat fibrous substance—such as "Mahoe" fibre (*Hibiscus elatus*). Planting out the seedling. The weeds to be cut close, and not hoed. Staking the plants.

HARVESTING.—When the trees have been planted close together, they will require thinning out about the fourth year, when about 25 per cent. of the trees may be uprooted. This process may be continued year by year until, at the end of the seventh year, only a half of the trees originally planted will be left, and these may be allowed to grow until they encroach too much on each other when a further thinning may be judiciously undertaken. The trees are uprooted and barked in the following manner :—The roots are sawn off at the stool and washed in water, and all the branches of the trees are cut off, the bark from them, and from the roots, being peeled or whittled off, care being taken not to remove any of the woody tissue. Root bark is more valuable than that from other parts of the tree, as it is richer in the alkaloids. Rings are cut round the stem at distances of eighteen inches apart, a longitudinal cut is then made along the stem, Thinning out the trees. Barking.

and the bark is lifted off in sections with a flat iron spatula, care being taken not to break the pieces of bark, which as a rule come off easily as they are full of sap. The bark is dried in the sun for three or four days; and, when dry, it is usually about one third of the weight of wet bark, and each tree of crown bark, about four or five years old will yield at least about a pound of the commercial article. The red bark trees will yield much more.

Drying the bark.

The bark is harvested from standing trees in four ways: namely,—1. Lopping, 2. Coppicing, 3. Shaving, 4. Mossing.

Lopping.—In this system the branches of the trees are lopped off, and the bark removed from them in the usual manner; the trees, in fact, are pollarded. Later on fresh branches shoot out, and, when they grow to a sufficient size, they are again lopped off. Formerly this system was much adopted, but lately it has given place to coppicing and shaving as these two methods give large crops, and do less harm to the trees.

The lopping system now discarded.

Coppicing.—The trees, when about six years old, are cut down to the ground, and barked, and shoots are allowed to grow up, which in their turn are cut down when they are sufficiently stout and strong to yield a good return of bark. The system is the same as that employed in harvesting cinnamon, and it has been fully described in Chapter VIII. In the case of trees that are destined to be coppiced, one or two suckers may be allowed to grow up from the lowest part of the stem, in order to give a greater surface from which bark may be removed. When the trees have been cut down usually a number of shoots spring up, and the stronger ones, to the number of from three to five, may be allowed to grow, the weaker ones being pruned out. It has been calculated that about three per cent. of coppiced trees die, and these must be replaced by fresh seedling plants.

The system of coppicing the same as that employed for cinnamon.

The weaker shoots to be cut.

Shaving.—This plan was invented by Moens, who did much to render cinchona cultivation successful in Java. It is a kind of whittling of the bark of the tree, and

M. Moens.

it may be done expeditiously with an ordinary spokeshave. The bark is shaved as near to the cambium layer as possible, without, however, reaching it. The *cambium* is that portion of the stem lying between the wood and the bark, and it consists of a thin layer of delicate cells full of the vital fluids of the tree. The bark is renewed quickly after shaving, but if the cambium zone be injured, fresh bark will not be formed at the seat of the injury. The new bark is always richer in quinine than the original bark, and thus the system of shaving has become general in the East. Some planters shave the tree all round the trunk, but this is not to be recommended—the best plan being to shave two strips from each side of the stem, and in this way the tree does not receive injury. In dry weather it is usual to tie dry grass over the shaved portions, but in most instances the trees if planted closely will do well without this precaution. The operation of shaving is easily learnt, and it is expeditious ; besides the shavings are very convenient for drying and packing, and crops may be harvested every seven months.

The cambium.

Bark renewed quickly after shaving.

New bark richer than the old.

The operation easy.

MOSSING.—This system was introduced by McIvor, the most distinguished of the able men who established the Indian cinchona plantations from the plants and seeds obtained in South America by the successful labours of Markham, Spruce, and Cross. The operation is performed in the following manner :—The bark of trees, eight years old and upwards, is removed as far as one can reach in alternate ribbon-like strips 1½ inches wide ; and, afterwards, the trunk is protected by a covering of moss tied on with some fibrous material. In damp weather the long wounds soon heal up, and in less than two years the denuded portions of the trees become covered with thick layers of bark richer in quinine than the original ones. In about a year after the stripping has been done, the bark that was left is to be removed, and the trees again mossed up. It is said that there appears to be no limit to the number of times the bark may be removed

Mr. McIvor.

How the mossing is done.

Renewed bark richer than the old bark.

Mossing in Jamaica.

in this manner. In Jamaica, the club-moss, *Lycopodium clavatum*, made into ropes was employed by Morris for mossing. Mossing in India is now said to be abandoned in favour of "shaving" or the Java system.

Drying to be done gradually.

DRYING AND PACKING.—The bark is usually dried in the sun on barbecues. It is better that the drying should be done gradually, and, for this reason, the bark must not be kept too long in the sun at first. In rainy weather the drying may be accomplished in well ventilated sheds in which a fire

Sun drying the best.

may be kept burning, or the bark may be speedily dessicated in an American evaporator. Sun drying, however, is the best, and the other methods should only be employed in cases of necessity. According to the method of harvesting,

Root bark richest in alkaloids.

and the part of the plant from which the product comes, the bark occurs in commerce in various forms. Thus there are the *root bark*, which is always the richest in alkaloids; the *quill bark*, which is that from the branches and small trunks rolled up into pipes and quills by the process of drying; the *shavings*, produced by the shaving method of harvesting; and *flat bark*, which is mostly that from large trunks, the bark being submitted to pressure so as to permit it to pack easily.

Packing the bark.

The dried bark is usually shipped in bales which vary in size according to the fancy of the planter; but it may be shipped in boxes or barrels, care being taken, however, to keep each kind of bark in a separate package. The bark is admitted through the Customs, without reference to source, as "Cinchona" or "Peruvian" bark. In manufacturer's bark, from 5 to 7 per cent. of quinine, exclusive of the alkaloids, is a saleable condition, and the value is based on the unit rate ruling at the time of selling and the quinine content of samples. Amsterdam is the principal market.

CASTOR SEEDS. *Ricinus communis.*

The castor oil plant, sometimes called "Palma Christi" on account of its beautiful palm-shaped leaves, is well known. A perennial, 5 to 8 feet high; cultivated in many tropical and sub-tropical countries, though in many parts it can scarcely

be said to be cultivated, for it grows spontaneously on most waste lands, and in some places it is a troublesome weed. The valuable properties of the plant were known in very ancient times, and seeds have been found in tombs in Egypt supposed to have been 4,000 years old. The oil was used by the Greeks and the Romans, and the plant is believed by some authorities to be the gourd mentioned in the Scriptures. The Romans, seeing a resemblance between the seed and the unpleasant insect now known as a tick, called both *Ricinus*, and this Latin name has been adopted by botanists present to indicate the genus of the present plant.

Grows wild in the West Indies.

History of the plant.

The oil has been used from time immemorial as a purgative medicine, and for lighting purposes; and, recently, it has been largely employed as a lubricant for machinery, watches, clocks, &c., and for the making of soaps, pomatum, and perfumed oils. It is one of the best and safest lamp oils known. It burns slowly and thus effects a saving, it gives a good white light, it is free from danger, and it gives very little soot. Owing to these advantages, it is used for lamps on all the Indian railways. The cold drawn oil gives the best light; indeed, one authority states that "no other oil can vie with this light, it being almost electrical in its brilliancy."

The use of the oil.

Its value as a lamp oil.

SOIL AND CLIMATE.—The plant is a hardy one, and it will stand a wide range of climate. In the tropics it grows from the sea level to a height of 5,000 feet, and it will thrive in the summer time in England and the Northern States of America. In temperate climates, however, the plant is an annual, whilst in the tropics it becomes a small perennial tree, attaining sometimes to a height of from twenty to thirty feet. The best soil is a rich, well-drained sandy or clayey loam; and light loose sandy and wet heavy soils must be avoided. It is said to improve the richness of soils on which it is grown; but this is an error, for the seeds contain much nitrogen, potash and phosphoric acid, and thus heavy crops

Wide range of climate.

The best soil.

The explanation of an error.

would remove considerable quantities of these substances from the soil. The plant has many roots which penetrate deeply, and, therefore by their decay they would open channels for the penetration of the atmosphere, and thus increase the valuable constituents of and add organic matter to the land, thereby temporarily increasing the available quantity of plant food, and so the error of imagining that the plant enriches the soil may be explained in this way.

The preparation of the land.

CULTIVATION.—Plants are propagated by seeds which are sown in the fields. The land is cleared, and prepared in the usual way; deep tillage, and subsequent harrowing, being necessary to render the soil open and free so that the roots

Soaking the seeds.

can penetrate easily. Before sowing, the seeds may, with advantage, be left to soak in water for twenty-four hours.

Distances.

Sown at distances of six feet by six, or eight feet by eight, in good rich land, from ten to fourteen lbs. of seed may be required per acre. The best time for sowing is just before

Sowing the seeds.

the rainy season commences. Four seeds should be planted in each hole, at a distance of six inches from each other; and, when the plants are from six to ten inches high, all but the strongest seedling should be pulled up. The seeds usually germinate in about ten days; the plants grow rapidly and commence to bear in four to six months from the time

Weeding and moulding up.

of sowing. The ground will have to be kept clear of weeds, and the plants may with advantage be moulded up occasionally. As the object of the planter is to produce trees with

Nipping back the stem.

many fruit-bearing branches, it will be necessary to nip back the main stem when it is making too rapid growth, or when about a foot high, otherwise few flowering spikes will result. The castor oil plant has few enemies, for most insects shun it; and for this reason it has been

Blights.

recommended, in cases of insect blights on other plants, that castor oil bushes should be planted at intervals in the affected fields. In older plants, however, the bark of the stem becomes attacked by various insects such as the

scale blight, *Coccus*, and the mite, *Acarus*. Should these pests appear to injure the trees, they may be killed by applying lime wash, or kerosine oil emulsion, to the affected stems with a brush. Insecticides.

CROPS.—There are two principal kinds of castor oil seeds cultivated—the large and the small varieties. The large seeds yield from 25 to 30 per cent. of oil, but the oil is of an inferior quality, and it is used only for lighting and lubricating purposes. The small seeds give from 38 to 40 per cent. of oil, which is of a finer quality, and this variety is the one from which the medicinal cold drawn oil is obtained. The plants commence to bear at the fourth month, and the crops will become larger as the trees increase in size. In India, sometimes a yield of 15 lbs. of seed is obtained from single trees; and, in general, it is reckoned that from fifteen to twenty-five bushels (bushel = 46 lbs.) are got from an acre of land under castor seed cultivation. There is a ready sale for the cleaned seed in the American and European markets, and the produce may be shipped in bags or in barrels. Varieties. The oil. Returns. The markets.

In harvesting, the spikes are gathered as soon as the capsules commence to turn brown; for, if they were left on the trees to ripen thoroughly, the crops would be lost as the capsules burst open suddenly with some force and scatter the seed to wide distances. The spikes, when cut off, are carried to the drying house, or they may be exposed to the sun on barbecues. During the day the spikes are turned over with a rake once or twice, so as to allow the lower layers to receive the rays of the sun. In from three to four days all the capsules will have burst, and then the seeds may be cleaned from the husks and foreign matter by winnowing. Should rain come on whilst the spikes are exposed out of doors, they should be raked into heaps, and covered up with tarpaulins, or boards. As the seeds "pop" to some distance it is usual to confine the drying-place by a board fence four The seeds dried in the sun. Winnowing.

or five feet high ; but, if a clear space of twelve feet can be left outside the drying layer of capsules, this fence may be dispensed with. The spikes should be spread in a thin layer of not more than six inches in depth, for the thinner the layer the quicker will be the drying.

MEDICINAL OIL.—Castor seed for the extraction of oil for medicinal purposes is imported chiefly from British India and Brazil. Particulars of the method of extraction are given in the chapter on oils. Bombay castor seed at present (June 1928) realises about £17 10*s.* a ton. Hull is the most important centre for crushing and preparation of castor oil for medicinal use. British pharmaceutical oil was recently quoted at 54*s.* per cwt.

CASTOR OIL PLANT (*Ricinus communis* L.) (Euphorbiaceæ).

A, Branch bearing flowering and fruiting spikes. B, Male flower. C, Branched stamens. D, Female flower in section. E, Seed, whole and in section. F, Embryo. G, Capsule—3-lobed containing 3 seeds. (B, C, F magnified. A, E, G reduced.)

[*After Baill. From "The Families of Flowering Plants," by J. Hutchinson.*

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CHAPTER XII

DRUGS.—*continued*

COCA. *Erythroxylon Coca* and *E. novogranatense.*

Habitat.

COCA consists of the dried leaves of a shrub growing wild in the Cinchona regions of the South American Andes at elevations of from 2,000 to 9,000 feet above the level of the sea. The plant is extensively cultivated in the warm mountain valleys of the eastern slopes of the Andes, and the leaves are universally chewed by the Indians—both men and women—and by many of the other inhabitants of New Granada, Bolivia, Peru, and the neighbouring countries. The chewing of the leaves exerts a pleasureable effect on the mind, and under the influence of the drug the Indians are able to perform long and rapid journeys, and to carry heavy loads without sleep or food. In New Granada, coca is called *spadic*, and Spruce states that an Indian with a chew of spadic in his cheek, will go two or three days without food and without feeling any desire to sleep. Markham, while travelling in the Cinchona districts, says he chewed coca very frequently, and besides the agreeable soothing feeling produced, he found that he could endure long abstinence from food with less inconvenience than he would otherwise have felt; it enabled him also to ascend precipitous mountain sides with a feeling of lightness and elasticity and without losing breath. The Indians sometimes chew the leaf alone and sometimes mixed with small quantities of lime or of the

Chewing the leaves.

Remarkable action of the drug when chewed.

Mr. Markham's experience.

Antiquity of the custom.

ashes of banana roots. The custom of masticating coca leaves is of great antiquity in Peru, and the Spaniards on arriving in that country found that the leaves were so highly valued as to be used in lieu of money.

Within recent years the drug has come to be extensively used as a tonic to the nervous and digestive systems, and its

COCA. *Erythroxylon Coca.*
1. Flower. 2. Ovary and Stigmas. 3. Fruit.

virtues are highly extolled by many medical men. An alkaloid, called *cocaine*, has been separated from the leaves, and it has been found to have the remarkable property of rendering various tissues of the body totally insensible, thus enabling certain surgical operations to be performed without pain. The alkaloid.

Proportion of the cocaine in the leaves.

The leaves contain only from a half to three quarters per cent. of cocaine, so that large quantities are consumed every year in the manufacture of the alkaloid alone.

The best soil.

SOIL AND CLIMATE.—The coca shrub is hardy; and, although it will grow on many kinds of soil, for its successful cultivation a rich and light soil is necessary. Well drained moist loams rich in humus are the most suitable; and, as the plants exhaust the land, judicious manuring will be necessary after heavy crops are reaped. Although the shrub is a native of the highlands of South America, one variety of it has been found to thrive at sea level in the West Indies in places where the air is usually moist and the soil suitable, but the lower slopes of the hills produce leaves richest in the alkaloid.

The best climate.

PROPAGATION.—The plant will grow from cuttings; but when it is cultivated to any extent, seedlings should be raised in nurseries. The beds are prepared in the usual way, and the seeds are strewn on the surface and lightly covered with fine earth. The seedlings are to be protected from the sun by the erection of thatched roofs in the manner described under the head of cinchona, and frequent watering is necessary until the plants are strong. The seeds will germinate in about a fortnight after sowing, and the plants may be put out into the fields when they are from eight to ten inches high.

Nurseries.

Germination.

CULTIVATION.—The land having been well tilled, so as to destroy the weeds and to render the soil light and free, the seedlings are planted at distances of six feet from each other, and this will allow over 1,200 shrubs to the acre. The employment of the general principles of cultivation is all that is required, for the plants do not need any special treatment.

Distances.

General principles of cultivation.

CROPS.—The first harvest may be looked for at the end of eighteen months from the time of planting, and the shrubs

will yield crops for forty years. The leaves are ready to gather when they become rigid, and when they crackle and break on bending, their size and colour not being regarded. Two, or three or even four crops may be obtained in the year from strong plants growing in rich soil. The leaves are picked singly, care being taken not to injure the buds, and on no account should the young leaves and shoots be plucked off. A fine dry day must be chosen for harvesting; and the picking should not be carried beyond noon in order that the leaves may be exposed for several hours in the sun to dry, for if they become damp they will ferment and turn to a dark colour, in which condition they are valueless. The drying is accomplished by spreading the leaves in thin layers on barbecues and lightly raking them over from time to time. In favourable weather the drying will be complete after three or four hours exposure to the sun, and then the leaves should be put in a dry place for a day or two and then packed.

Gathering the leaves.

The number of crops.

The leaves to be kept dry.

Leaves dried in the sun.

In South America coca is packed, by means of a wooden press, in square bales covered with coarse cloth and weighing about 25 lbs. each. Two bales are then tied together and enveloped in dried plantain leaves, and three of these larger packages weighing about 150 lbs. make up a mule load. As, however, coca is easily damaged by heat and moisture, the best way is to seal it up as soon as it is dry in packages similar to those used for tea, and they should be shipped without delay, for the leaves keep in good condition much longer in cold and temperate climates than in the tropics.

Packing.

The drug damaged by heat and moisture.

Coca, however, is one of the useful medicinal plants that come under the Abuse of Opiates Ordinances,[1] and the cultivation and sale is now carried on by licence or under official control. The chief sources of coca-leaves of commerce are Peru and Bolivia, known as "Truxillo" and "Huanuco" respectively. Java is also an important source; Ceylon once figured largely in the trade, but for the reason given above the cultivation is now neglected.

1 International Convention signed at Geneva, February 19, 1925.

Jalap. *Ipomœa purga.*

Habitat. The jalap plant is a beautiful climber, with rose-coloured flowers, found growing wild in the mountains of Mexico, and it derives its name from the city of Xalapa which has long been the emporium of the jalap trade.

Description of the drug. Jalap occurs in commerce in dry pear-shaped masses usually called tubers, and varying in size from that of a small nut to that of an orange. The so-called tubers are, however, simply enlarged divisions of the root known botanically as *tubercules*. A tuber is an enlarged underground stem, and the term is therefore incorrectly applied to the transformed roots of the jalap plant.

The cultivation is recommended on a small scale by those possessing suitable land at the proper elevation, and as a secondary crop it may well engage the attention of small proprietors.

A rich soil necessary. Soil and Climate.—Jalap requires a rich soil for the crop is an exhausting one. Formerly the plant was grown amongst the Cinchona trees, but this system had to be abandoned for the jalap throve at the expense of the Cinchonas. A rich deep vegetable sandy loam is best suited to the cultivation; and. although moisture is necessary for the welfare of the

Climate. plant, undrained soils are fatal to it. In its natural condition, the jalap plant is found "in shady mountain woods, at "an elevation of from 5,000 to 8,000 feet above the sea, in "regions where rain falls almost daily, and where the tempera-"ture during the day ranges between 60° and 70° Fahr." A climate as near as possible approaching this one should be chosen, but it is quite possible that the plant may yield profitable returns at much lower elevations.

Cuttings. Propagation.—Plants may be obtained from cuttings of the side shoots set in a sandy soil in a shady place and kept constantly moist; but for cultivation on a considerable scale,

Tubercules. the smaller tubercules should be planted, or cuttings of underground stems may be buried a few inches below the surface. The tubercules should on no account be exposed

to the sun, or they will lose their vitality, and they should be planted out as soon as possible after they have been dug out of the ground.

Trenching.

CULTIVATION.—The land should be well tilled and trenched to the depth of two feet. The trenches may then with advantage be partially filled with compost or farm-yard manure, which should be covered with surface soil. The tubercules are planted, in the trenches, one foot apart and to the depth of about six inches. When the vines grow, stakes must be firmly fixed in the ground for them to run on, in fact the creeper is treated in the same manner as are yams or green peas. After the plants have made some growth they should be moulded up with earth taken out of the trench, and weeding is done at intervals so as to keep the land free from weeds.

Weeding.

Returns.

CROPS.—At the third year a return may be expected, and it is found in India that at least 1,000 lbs. of dry tubercules can be gathered from an acre under jalap cultivation, and crops may be reaped at every third year thereafter. It is advisable, however, to lift two or three plots one year, whilst others are left undisturbed until the following year, and so on. In this manner crops will be got every year, and there will be less difficulty in preparing the product for the markets, as there will be fewer tubercules to dry at a given time. The drying process is a difficult and trying one, for 70 per cent. of the weight has to be evaporated ; and it frequently happens when the tubercules are dried in the sun that there is a considerable loss on account of some becoming mouldy and others becoming subjects of fermentation. This loss may be prevented to a great extent by gashing the tubercules, or by cutting them up into slices, but jalap prepared in this way fetches a lower price in the English and American markets. The American evaporator answers very well, but too much heat is to be avoided as it spoils the product. The Indians of Mexico prepare jalap in the following way :—The tuber-

How to obtain yearly crops.

Drying

Mouldiness and fermentation.

The Mexican method of drying.

cules, when gathered, are freed from earth and foreign matter and then hung up in a net over a wood fire kept constantly burning in the hut; and, in consequence, the jalap acquires a smoky flavour which is considered by buyers to be one of the tests of "good tubers." The method of the Mexican Indians may be adopted by those engaging in jalap cultivation.

Wood fires.

Rough inexpensive trash sheds can be constructed, and the tubercules may be dried slowly in them over wood fires, at a slight outlay and with little trouble. To prevent accidents the fires should be put out at nights, for the smoke and the heat will prevent fermentation and mouldiness.

The purchasers of the drug.

As jalap is used in medicine alone, in order to obtain the highest prices, it is necessary to place the product on the market in the form best known to the wholesale druggists—who are the principal purchasers. The *British Pharmacopœia*, which is published under the authority of the Imperial Parliament, contains accurate descriptions of all the drugs recognised officially by the General Medical Council of the United Kingdom. The following is the description of Jalap contained in this publication :—

JALAP.—The dried tubercules of *Ipomœa* (Exogonium) *purga* . . . Imported from Mexico.

Official description of the drug.

Characters.—Varying from the size of a nut to that of an orange, ovoid, the larger tubercules frequently incised, covered with a thin brown wrinkled cuticle; presenting, when cut, a yellowish-grey colour, with dark brown concentric circles. Yields from 9 to 11 per cent. of resin. A recent quotation for 11 per cent. quality is 16*d.* per lb.

SARSAPARILLA. *Smilax ornata.*

Habitat.

The well-known drug Sarsaparilla consists of the cord-like roots of a slender climbing plant, inhabiting the forests of the lower lands of Central America. The drug is obtained from several varieties of *Smilax*, but the kind known best and

fetching the highest price is "Jamaica Sarsaparilla"—the dried roots of *S. ornata*. This species, although cultivated sparingly in the island, is not a native of Jamaica, the association of names being due to the fact that considerable quantities of the drug have been imported from Central America into England by way of Jamaica.

Description of the drug.

Dr. Garrod, in his work on Materia Medica, thus describes the product:—"Sarsaparilla consists of the rhizome or root-"stock, called also the chump, with numerous roots attached, "generally several feet long, but of different lengths and "thickness in different varieties; these roots often give off "secondary rootlets, which are themselves again finely sub-"divided; they are then said to be bearded." A native-grown Sarsaparilla in Jamaica, known in the trade as "Native Jamaica," is believed to be *Smilax utilis*, and "Vera Cruz" or "Mexican" the root of *S. medica*.

The best soil.

Climate.

SOIL AND CLIMATE.—The best soil is a light, well-drained sandy loam, but the plant may be grown on alluvial flats, and on newly cleared land as long as the soil contains a large proportion of the original humus of the forest. The climate should be hot and moist, and, therefore, the cultivation is unsuited to the highlands.

Suckers.

Layers.

Seeds.

Nurseries.

Cuttings.

PROPAGATION.—Plants may be raised from suckers from the roots, from layers, or from seed. The suckers are divided with a portion of the root attached, and planted out in rainy weather. When reproduction is effected by layers, the vine or stem is lifted off the ground, the soil is loosened, and the vine buried slightly and kept firmly in position by pegging it down with a forked stick; it will then root freely, and form a new stock. The seeds are enclosed in berries which are borne in great numbers in bunches hanging from the vine like grapes. Seeds are sown in nursery beds in the usual manner, and the seedlings are transplanted when they are five or six inches high. Plants may also be reproduced by

cuttings and bear crops earlier than when raised from seed.

Distances.

CULTIVATION.—The ground should be broken up by good tillage, and holes dug at distances of six feet by seven—the extra foot between the lines increasing the facilities for weeding and harvesting the crops. These distances will allow 42 square feet of surface to each plant, and will

Support for the vines.

enable 1,037 plants to be cultivated on every acre. The ground must be kept weeded, and stakes or trellises will have to be arranged for the vines to climb over. The plant grows something like the common yam.

Gathering the harvest.

CROPS.—The cultivation will give a return in from two to three years, and the roots may be harvested every year after the first crop is gathered. The roots are carefully dug up and cut off near to the stock, which is then moulded up with surface soil. Fresh roots will soon spring out, and they will

Cleaning the roots.

grow rapidly. The roots, after being dug up, are freed from adhering earthy particles; and sometimes, to clean them properly, it is necessary to wash them in water. They are

Packing.

then dried in the sun, and afterwards tied up in bundles and packed in bales for export.

Returns per acre.

Morris records that "the first crop in Jamaica is said to yield as much as 20 lbs. of dried roots per plant." The negroes who grow it usually plant Sarsaparilla at about 20 feet apart with other crops. The vines are trained to stakes and trellises. The first crop is reaped in about two years and a half from the time of planting. When prices are high the gross returns on Sarsaparilla cultivation is very

Bundles for export.

great. The market for this product is, however, very limited. For export it is usual to tie up the roots in bundles about a foot or eighteen inches long and weighing from 12 lbs. to 20 lbs. each, and these bundles are packed in bales weighing from 80 lbs. to 100 lbs or more. As "Radix Sarsæ" the drug was at one time official in the British Pharmacopœia. It is still imported, the value averaging 2*s.* per lb.

CAMPHOR. *Cinnamomum camphora.*

The camphor tree is an evergreen, upwards of 30 feet high, but very old trees may be 90 to 100 feet high with a trunk 2 to 3 feet in diameter. The fruit is a small berry with a single seed resembling that of a sweet pea. Native of China, Formosa and Japan, it has been cultivated experimentally in North, South, East, and West Africa, West Indies, India, Burma, Federated Malay States, Ceylon, Florida, California, &c., with a view to the production of camphor from the wood, but nowhere does it appear to have got beyond the experimental stage, though some success has been met with in the production of camphor from the leaves —notably in Florida and Tanganyika. Japan with its Formosan production, still controls the market in camphor. The tree is useful for ornamental purposes, for which it is largely grown in Southern Europe and South America. Plants are propagated by seed or cuttings raised in nurseries and planted out in the field, or positions intended to be permanent, at distances of from 10 to 15 feet. Where it is intended to obtain camphor from the leaves by distilling loppings, planting as hedges is suggested. Seeds (usually the berries are sown) may take from two to six months to germinate, and the percentage of germination appears to be always uncertain, so that fresh seed for sowing is of special importance. Some recent investigations by Russell (Florida) go to show that when the pulp is removed before sowing, the percentage of germination is considerably increased. The soil should be a good sandy loam or fairly rich and well drained. A warm climate, though not necessarily tropical, is essential. For instance, the camphor plantations in Amani, Tanganyika, where camphor has been produced on an experimental scale from the leaves, are situated at about 1,500 to 3,000 feet above sea level, and in Burma the tree has been found to thrive at from 3,000 to 4,000 feet.

Description of the tree.

Japan and Formosa the chief sources.

The yield of camphor and oil is very uncertain ; it varies

Yield of solid camphor uncertain.

very considerably even in Formosa, where trees in the north have been found to give as high as 100 parts of camphor to 75 parts of oil, while in the extreme south the proportion of oil to camphor is considerably higher. W. R. Price, who travelled in Formosa in 1912, gives a proof, by experiment, that the same tree will produce more camphor and less oil in the winter. L. A. Boodle has examined Formosan woods of "true," and "shu" (tree yielding oil only) in the laboratory at Kew, and suggests that the anatomical differences noted in the two specimens might perhaps be dependent entirely on the conditions of growth, but in order to gain any opinion on the subject it would be necessary to examine many specimens and to obtain information as to the habitats, &c., of the trees from which they were cut. Other hypotheses have been put forward to account for this difference—more particularly in reference to cultivated trees in various parts of the world. Be that as it may, however, it is suggested that the tree is worth growing for ornament, as shelter for the smaller plants or as hedges. The camphor is obtained from the wood of old trees and from the leaves and loppings of trees by distillation.

Camphor obtained from wood and leaves.

It has been found (Perfumery and Essential Oil Record, June 1920, p. 226) that "it is an established fact that "camphor wood of one or two years' growth contains "relatively small proportions of camphor, whereas the leaves "contain relatively large percentages. The quantity of "wood which is removed by severe pruning is greatly in "excess of the leaves. Severe pruning, therefore, increases "the weight and bulk of the green material to be handled "in the field and at the distilling plant without appreciably "increasing the weight per acre of the camphor obtained. "Considerable expense is also incurred in distilling this "bulky camphor brush, which does not contain sufficient "gum camphor to pay the cost of handling and distilling "and of removing the refuse from the stills. Furthermore,

"it has been demonstrated experimentally that as the "camphor tree increases in age the proportion of camphor "in the trunk and limbs also increases. The leaves and "young limb growth always contain relatively large amounts "of camphor, hence if only the leaves and new growth are "removed each dormant season, the remaining old limbs "and trunk will be gradually increasing in camphor content, "and if at any future time it becomes desirable or expedient "to cut down and distil the whole tree, the yield of camphor "obtained will be large in comparison with the bulk and "weight of the green material handled."

Hand clipping . . . "has become so expensive as "seriously to threaten the profitable production of gum "camphor in the Gulf States," and "during the winter of "1915–16 a mechanical means for clipping the leaves and "twigs was constructed at Orlando, Florida" (and the particulars herewith are from an official Bulletin on the subject by G. H. Russell). "This machine was given a "trial in the summer of 1916 at the camphor planta- "tion, Satsuma Heights, Florida, and was subsequently "improved, proving beyond a doubt the practicability of "using machinery for clipping camphor trees." . . . "The "operation of the machine is not difficult, requiring only the "necessary attention and care given to any similar farm "machinery." Three men—when mules are employed—or two, it is believed, would be able to successfully operate machines driven by tractors.

Machine for harvesting leaves.

The method of preparation of the natural product is in itself a simple process, and in Japan and Formosa is carried out by very crude methods. "The wood (from old trees) "is chopped into small pieces and placed in a still, which "consists of a barrel having a perforated bottom. This "barrel is placed over a flat kettle or boiler and heat applied "by means of a fire below. The steam generated in the "kettle carries the camphor and camphor oil with it in the "form of vapour, and the products of distillation are led

Method of extraction.

"by means of a sloping bamboo tube from the top of th
"still into a condenser which consists of a box divided int
"a number of compartments, which is inverted and place
"in another shallower but larger box containing a layer o
"water in the bottom. This layer of water acts as a seal t
"prevent the escape of the camphor and oil from the con
"denser, and also to cool the vapours. The crude campho
"and oil is skimmed from the surface of the water an
"scraped from the sides of the condenser, the campho
"being as far as possible separated from the oil by pressure
"Most of the crude camphor is exported to Europe an
"purified there." "Various methods are used for purifica
"tion; *e.g.* (1) crystallisation from various solvents an
"subsequent purification in centrifugal machines; (2) re
"moval of water and oil in hydraulic presses; (3) drying i
"special chambers containing calcium chloride. The fina
"refining is a process of sublimation in which the campho
"is usually mixed with charcoal or lime." Purified campho
appears on the market in three forms, obtained by subliming in retorts, "flowers" obtained by sublimation, and the well-known blocks or cubes formed from the flowers by hydraulic pressure.

Uses of camphor.

Camphor is largely used, the greater proportion probably in the manufacture of "Xylonite," or celluloid, and in smaller proportion for medicinal and pharmaceutical purposes, &c. camphorated oil is a preparation of olive oil and camphor.

Prices.

Refined camphor in June 1926 was realising on the London market—spot quotations 3*s.* 4*d.* per lb., and for May–June shipments 2*s.* 11*d.* c.i.f. for Japanese "slabs," and "flowers" were quoted at 3*s.* 6*d.* per lb. In 1924 the imports o camphor into the United Kingdom from Japan (including Formosa), the principal source, were 3.543 cwts., value £102,457. Camphor oil at the same time was sold at about 62*s.* 6*d.* per cwt. for "brown" and "white" Japanese. Prior to the discovery of "Safrol" in camphor oil about 1899 it was regarded as being more or less a waste product.

and although this has increased in importance accordingly, as a commercial article, the "Safrol" content in the oil appears, like the camphor yield, to be somewhat uncertain, and these facts should always be borne in mind when undertaking cultivation with these productions in view. A serious competitor in synthetic camphor must also be kept in view. It now seems to be sufficiently well established as to be causing some anxiety in Japan—where the monopoly in the natural product is held—as to the future under cultivation. The progress of the synthetic product is also eloquent of the growing possibilities of a situation arising in camphor production, similar to that in vegetable dye production.

Synthetic camphor.

The following papers might be consulted :

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(2) "Distillation of Camphor" in Kew Bull., 1907, pp. 89–90.
(3) "Camphor (*Cinnamomum Camphora*)" in Kew Bull. 1899, pp. 57–68.
(4) "Camphor Cultivation" in Perfumery and Essential Oil Record, Jan. 1919, p. 3.
(5) "On Camphor Oil and the Possibility of Increasing Camphor Cultivation in the British Empire," *Ibid.*, March 1919, pp. 57–59.
(6) "A Machine for Trimming Camphor Trees," *Ibid.*, June 1920, pp. 226–7.
(7) "Variability of the Camphor Yield in *Cinnamomum Camphora*," in Kew Bull., No. 4, 1921, pp. 129–35. (H.M. Stationery Office, London.)

CROTON. *Croton Tiglium.*

A shrub or small tree 15 to 20 feet high. Fruit 3-celled, 3-seeded, each seed ovoid, about ½ inch long, slightly less wide, a native of India and Malaya; introduced to many tropical countries. The seeds yield the "Croton Oil" of the British Pharmacopœia. The bark is poisonous. May be propagated by seeds and grows freely. The market for the seeds may easily be overdone, as the demand is more or less

limited. The yield of oil expressed from the seeds is about 50 per cent. The oil requires careful handling, as it has a blistering effect on the skin. The oil mixes with alcohol and might be tried like castor oil as a denaturant of industrial spirit.

Cascarilla or Sweet Bark. *Croton Eluteria.*

A small shrub or tree, native of the Bahamas. The bark is aromatic, bitter and tonic. It comes in in bales and in barrels; in June 1926 it was quoted at 3*s.* 3*d.* to 3*s.* 6*d.* per lb. The twigs, branches and small stems are collected and dried for exportation, usually in "quills" 5–10 cm. long and 4–10 cm. broad.

Cubebs. *Piper Cubeba.*

A climbing shrub, native of Java and the Moluccan Islands; cultivated in Java, Sumatra, Borneo, &c. The fruits are globular, $\frac{1}{4}$ inch in diameter, short stalked and bluntly apiculate, smooth when fresh, wrinkled when dry; they closely resemble those of ordinary pepper (*Piper nigrum*), and are known in commerce as "cubebs," sometimes called "Java pepper." Both the fruits and an oil extracted from them by distillation (about 10–18 per cent.) are official in the British Pharmacopœia. Supplies of the fruit come chiefly from Java and Singapore, valued (June 1926) at £13 per cwt. They are collected while green, dried in the sun, becoming almost black in the process. The cultivation is easy, and a convenient way is by planting at the foot of shade trees in coffee plantations, &c.

Areca Nut. *Areca catechu.*

A palm growing 40 to 50 feet high and upwards. Fruits about 2 inches long, orange or bright red in colour when ripe, single-seeded. The seeds are hard, short and cone-like. Cultivated in India, Ceylon, South China, Philippine Islands, Malaya, Siam, Borneo, &c., in the East, Zanzibar,

Tanganyika and parts of East Africa. The nuts or seeds are used for medicinal purposes, and in India and other Eastern countries as a masticatory or for chewing together with "betel pepper" (*Piper betle*). Preparations of the nut are used for tooth-paste and powder in Europe, and an important use is that of the powdered seeds as a vermifuge for dogs. Under cultivation the palm requires a rich, damp soil, moist atmosphere and a high temperature. The seeds are removed from the fruits when ripe, and before packing for export it is advisable to boil them in lime-water and afterwards dry them. They are imported into this country in bags, largely from Ceylon and India, the prices ruling at the present time being about 45*s.* per cwt.

KOLA NUT. *Cola acuminata.*

A tree found in West Africa, introduced to most tropical countries and naturalised in the West Indies. The fruits contain upwards of fifteen seeds, which vary in colour, usually white or red, sometimes an intermediate shade. The kernel is the "kola nut" of commerce, which when dry breaks up into two parts (cotyledons)—this is the best, but there are other varieties which break up into from 4 to 6 cotyledons that are not of much value commercially for medicinal purposes—of a dull reddish-brown colour, from 1 to 2 inches long, one side more or less flat, the other rounded. In the home markets the dried nuts realise about 2½*d.* per lb., and there is a good trade between West Africa and the European markets; also a large trade in the fresh nuts in West Africa itself, and to some extent between West Africa and Bahia. The dried nuts contain about 2 per cent. or more of caffeine, and in Europe are regarded as fairly efficient substitutes for tea or coffee. The fresh nuts in West Africa are eaten by the natives as a stimulant, forming an important article of diet in their daily life. For transport, they are carefully packed in baskets with moist leaves—usually those of "bal" (*Cola cordifolia*) or *Thauma-*

Description of fruits and seeds.

Uses.

tococcus Danielli—and may carry in good condition for thirty days or so, the price varying in the countries of production, according to the distance conveyed and cost of transport, from 3*d.* to 1*s.* or more per hundred, or salt is sometimes bartered for the nuts. The requirements under cultivation are a tropical climate, a rainfall of 50 inches and upwards, a deep, rich, and well-drained soil and moderate shade. Plants may be propagated by seeds, cuttings, or layers. Seeds germinate in about a month, and young plants may be raised in nursery beds, but as they do not transplant well it is best to establish them in bamboo pots until large enough to plant out in permanent places. In the plantation the young plants should be put out at distances of from 20 to 30 feet, or wide enough apart to admit of shade trees being intermixed. Bananas make good shade in the early stages, and later large trees, such as "Indian walnut" (*Albizzia Lebbek*) or "rain tree" (*Pithecolobium Saman*). Trees raised from seed begin to bear a small amount of fruit when five or six years old, the produce increasing yearly until the tree matures. A remunerative crop may be expected after about ten years, when a single tree should yield an average of 120 lbs. annually.

Transport.

Cultivation.

Shade trees.

IPECACUANHA. *Psychotria Ipecacuanha.*

A low shrub, about 18 inches high. Roots more or less creeping horizontally, annulated, in commercial specimens about $\frac{1}{8}$ inch in diameter. Native of Brazil; cultivated in the Straits Settlements. The cultivation appears to be somewhat uncertain. It has succeeded in comparatively few places notwithstanding efforts to establish it in various countries. Johore and Selangor seem to be the only countries, so far, outside Brazil where success on a commercial scale has been attained. The plant may be propagated by cuttings and layers, and any broken piece of the annulated roots will make a new plant. A soil rich in humus, well-drained, a moist atmosphere and a sheltered,

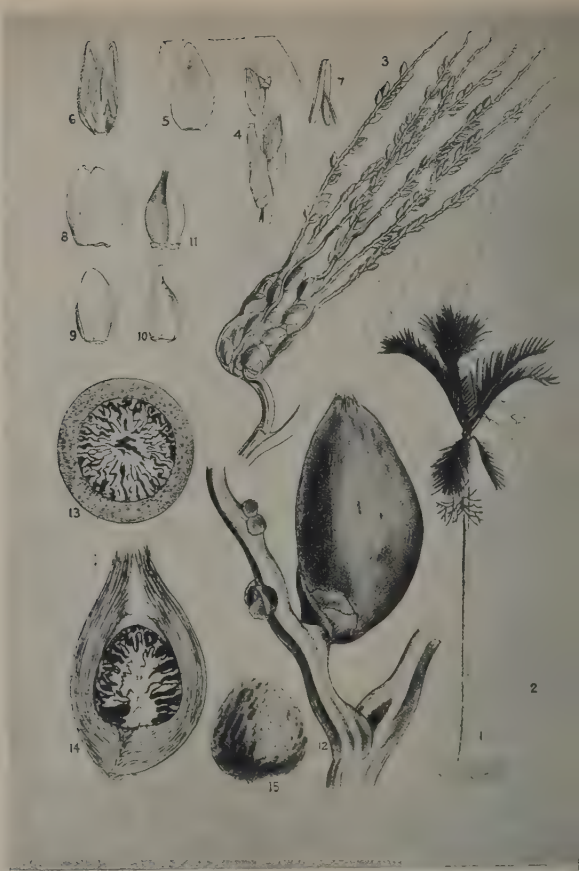
Description of plant.

Cultivation.

"IPECACUANHA" (*Psychotria Ipecacuanha*).

A.—1, Plant (reduced) showing annulated and fibrous roots. 2, Leaf. 3, An annulated root (slightly enlarged), the part that comes into commerce for medicinal purposes. 4, Capitulum (flower-head, slightly enlarged). 5, 6, 7, Sections of flower, showing dimorphic character (see p. 32, arrangement of stamens and pistils). B.—1, Portion of young plant (reduced): *a*, stem; *b*, leaves; *c*, fruit. 2, 3, Microscopical sections (trans. and long) of young stem about one year old. 4, 5, Microscopical sections (trans. and long.) of the root. 6, Two portions of the annulated root, bearing leaf-buds, showing the way in which the plant may be propagated. 7, Top of young plant.

[*From Trans. Royal Society, Edinburgh, xxvi, tt.* 31, 32.



ARECA NUT PALM (*Areca Catechu*).

1, Tree (much reduced). 2, Portion of a leaf (reduced). 3, Small pa of a spadix (reduced). 4–11, Parts of the male and female flowers (e larged). 12, A ripe fruit. 13–14, Transverse and vertical sections of see 15, Seed (reduced).

[*From "Medicinal Plants," by Drs. Bentley and Trime*

shady situation are essential conditions. Artificial shade is recommended—the usual temporary structures of forked supports and palm leaves. When planted under trees the drip from the leaves is liable to injure the plants, though they are said to grow well under the shade of palms such as *Euterpe oleracea*, *Oenocarpus Bacaba*, &c. The plant grows freely, but the root is of comparatively slow growth, taking perhaps three or four years to reach a profitable size. Collection of the root from well-established plants may go on nearly the year round. Drying in the sun or under cover in rainy weather is all the preparation required, and it may occupy only a few days before packing for export. The root comes in bales chiefly from Matto Grosso and Minas Geraes, the prices being quoted on the London market (June 1926) at 14*s.* 6*d.* per lb., whilst in the early part of 1927 for some unaccountable reason stocks were scarce and prices rose to 20*s.* and more per lb. East Indian, which is about equal in appearance and alkaloid content, realises about the same price per lb., but supplies have been short in recent years.

Cultivation.

Trade.

PAPAW. *Carica papaya.*

A small tree, 15 to 20 feet high, usually unbranched. Fruits nearly round or oblong, 8 to 12 inches long, more or less furrowed, yellowish when ripe and not unlike a large melon (hence the name "melon tree" sometimes given). Many seeded, the seeds being small, mucilaginous, black. The male and female flowers are developed on separate trees. "Papain" is the dried milk or juice of the fruit. It is obtained by scratching or lightly incising the surface of the fruit while green, somewhat after the manner of extracting opium from poppy-heads. The receptacles in which it is collected should not be of metal and the hands of the collectors require protection. Porcelain or glass-lined pans are recommended in the Philippines to evaporate the juice. The product is ready for export after being dried, when it should be white and granulated. In Montserrat the peasants

Description (see illustration of fruiting top and section of fruit, reduced).

Extraction of papain.

PAPAW (*Carica Papaya* L.) AND FRUIT IN SECTIONS.

A, inflorescence. B, longitudinal section of flower. C, stamens. D, ovary. E, cross-section of same. F, seed.

[*From "The Families of Flowering Plants," by J. Hutchinson.*

collect the juice in calabashes into which a small quantity of water is first placed. As the juice falls into the water it thickens to the consistency of ice-cream in which condition the buyers obtain it, afterwards drying it for shipment. Another method of preparation recommended in Kew Bulletin (1897, p. 107) is to mix the collected juice with twice its own volume of rectified spirit, filter the mixture after standing a few hours, dry at ordinary atmospheric temperature, powder, and keep in stoppered bottles. A similar method is recommended by Watt ("Commercial Products of India"), and by Watts (Agric. News Barbados, i, 1902, pp. 4-5); the last-mentioned author further suggests sheets of glass, or brown linen stretched on light wooden frames of a convenient size for drying, and an ordinary coffee-grinder for reducing the dried extract to powder. "Papain" was quoted (June 1926) at 15*s.* per lb. in London. Cultivation is easy; propagated by seed, plants flourish on rubbish heaps or any out-of-the-way corner in the neighbourhood of native dwellings and farms, where they are usually self-sown. Trees come to maturity in about a year, or earlier for green fruits, yielding fifty fruits or so, an average tree producing about ¼ lb. of granulated extract. Seed sown about 1 inch apart in prepared nursery beds or in shallow boxes should germinate in from two to six weeks, and when about 4 to 6 inches or even a foot high, they may be transplanted not less than 10 feet apart in permanent places. Commonly in the tropics one sees plants that are self-sown growing quite freely in situations similar to those mentioned above. Provided it is well worked and the drainage is good, almost any soil is suitable, but an open, rich, loamy soil is recommended. From three to five years is given as the life of a "papaw" tree. Manuring is not likely to prolong the life, though it would be an advantage as the trees mature, towards improving the supply of green fruit, from which the papain is obtained. In the Philippines —one of the chief commercial sources of papain—a liberal

Preparation for shipment.

Cultivation.

Soil.

supply of stable manure is advised, or of commercial fertilisers, organic nitrogen being said to be especially desirable. Some further particulars on the cultivation, &c., will be found in "Manual of Tropical and Sub-tropical Fruits," by William Popenoe—"The Papaya"—pp. 225–40 (see reference at end of chapter on Fruits.)

Medicinal plants under official control.

There are certain useful medicinal plants that come under the Abuse of Opiates Ordinances,[1] and the cultivation and sale is carried on only under licence or under official control; *e.g.* "Cannabis Indica" (*Cannabis sativa*, Linn.), cultivated in hot countries as a drug and in cool countries as a fibre plant. The drug is strongly narcotic and appears in three forms: "bhang"—dried leaves and flowering shoots, "charas" a resinous substance, and "ganja"—the dried flowering tops of the female plant: imported from India chiefly, where the cultivation and sale is carried on only under licence, and similar legal restrictions exist in Kenya, Nigeria, British Guiana, S. Africa, Angola, &c. Other instances of official control might be given, but the above is mentioned to show that cultivation is more or less inadvisable. In the same category may be placed "opium" (*Papaver somniferum*), "coca" (*Erythroxylon Coca*), "stramonium" (*Datura Stramonium*), &c.

REFERENCE.

"A Text Book of Materia Medica," by H. G. Greenish, pp. 1–568, illustrated. (J. & A. Churchill, London, 1920.)

[1] See foot-note under "Coca" on p. 237.

CHAPTER XIII

DYES AND TANS

ANATTO. *Bixa Orellana*

A SHRUB growing 10 feet or so in height, native of tropical America and widely spread in the tropics by cultivation, having become naturalised in West Africa and other parts.

The seeds yield the annatto of commerce, an orange or yellow dye; but the demand for the commodity is more or less stationary and has always been distinctly limited.

Modern uses of the dye.

At the present time anatto is used principally as a colouring for butter and some kinds of cheese, and as a dye for calico, silk, wool, skins, feathers, ivory, bone and such like. The dye produces a fast colour of a fine tint, and it is sometimes used to give a deeper shade to simple yellow dyes. A red colour, as well as a yellow one, can be obtained from anatto.

The dye produces two colours.

The handsome appearance of the shrub, however, makes it a desirable subject for ornamental purposes, especially as a hedge plant, since cattle and goats are said not to eat the leaves.

A hardy plant.

SOIL AND CLIMATE.—Anatto is a hardy plant, and it will grow, in suitable climates, on almost any soil except those soils that are swampy. Although it will grow and yield crops in places where the soil is poor, it will give much larger returns when cultivated on rich lands such as the banks of rivers and alluvial well drained flats. The plant grows from the sea level to elevations of 2,000 feet; and, in Ceylon, it thrives up to 3,000 feet above the sea. The best climate,

The best soils.

Climate.

however, is a moist one where the mean temperature ranges from 75° to 80° Fahr., and the rainfall is abundant.

Nurseries. PROPAGATION.—The plant is grown entirely from seed, which should be sown before it is perfectly dry in nursery beds made in a cool shady place. Or, several seeds may be planted in specially prepared beds in the fields; and, when the plants are about a foot high, all but the strongest one in each hole should be pulled up. The seedlings will be fit to be put out from the nurseries in about four months from the time of sowing, and they should be transplanted in rainy weather, when, if proper care be taken, but few of them will fail to take root in the fields.

Planting at stake.

Distances. CULTIVATION.—The land having been lined off at distances of from six to twelve feet, holes are to be dug and filled in as described in former chapters. The distances will depend on the character of the soil; on hill sides, where the soil is somewhat poor, the lesser distances may be employed, but on rich flat lands, even fifteen feet apart may not be sufficient to allow for the luxuriant growth of the trees. The seedlings, which should be from six to eight inches high, are then planted in the filled holes, and the land is to be kept clear of weeds, which should be hoed up and buried in trenches between the plants.

Planting out the seedlings.

Early crops. CROPS.—Full crops may be expected in three or four years but seeds may be gathered in eighteen months or even earlier. The author recently planted a patch of anatto, and many of the young plants flowered in less than a year from the time of sowing the seed. It has been calculated that the first full crop will yield about five hundredweights of seed to the acre, and the returns will increase for several years afterwards. When the capsules split open and disclose the seeds, they are cut off by women and children and carried to sheds, where the seeds are extracted and then dried in the sun. They are afterwards packed in barrels for shipment,

Full crops.

Gathering the crops.

Packing.

but the packing should not be done until the seeds are perfectly dry ; for, otherwise, they will become mouldy, or fermentation will be set up, and then the colour will be destroyed and the product will be valueless.

PREPARATION OF ANATTO.—The seeds are valuable solely for the reddish-yellow waxy *testa* which envelops them, and sometimes this is removed and shipped in cakes or rolls. The former is known in commerce as roll or flag anatto, and the latter as cake anatto, and ten pounds of the seeds will give at least a pound of the cake. Cake and roll anatto.

The preparation of anatto is very simple. The freshly gathered seeds are put in a tub, and boiling water is thrown on them, the mass being frequently stirred so as to wash off the waxy testa from the seeds. After some days the mass is passed through a sieve so as to separate the seeds, which should come away free from the dye. The liquid is then left for a week to ferment, and to allow the dye to subside to the bottom of the vessel, and the clear water is decanted off. The deposited dye is afterwards removed to shallow pans, in order that the excess of moisture may be evaporated in the shade. When the substance is of the consistency of putty, it may be made into rolls of two or three pounds weight each, and wrapped in banana leaves, and it then becomes the flag or roll anatto—which is exported in great quantity from Brazil. It may, however, be allowed to become drier by a longer exposure in shallow pans, and then it can be moulded into square cakes weighing eight or ten pounds each, which should be wrapped in banana leaves. The cakes are usually packed for export in casks containing five hundredweight of the product. Cake anatto is brown externally, but the inside is of a reddish or yellowish colour ; and in this form it fetches the highest price in the markets. The cakes should be thoroughly dry before they are packed, to prevent them losing their value by becoming mouldy after they are shipped. Preparation of anatto. Sieves. Fermentation. Evaporation. Anatto wrapped in banana leaves. Cake anatto.

In the French colony of Guadeloupe, where roucou is ex-

The Guadeloupe process.

tensively cultivated, a different mode of preparation has been adopted. The seeds are thoroughly crushed between rollers,

Crushing the seeds.

so that they come out as fine powder intimately mixed with the dye. The product is then put into water, and when it has subsided to the bottom, the surface water is run off, and the paste is boiled for four or five hours. It is afterwards put in boxes pierced at the bottom with holes that are covered with a cloth so as to prevent the paste passing through. A

Pressing out the moisture.

board is placed on the top of the paste, and weighted down, so as to press out the excess of moisture through the bottom holes. The paste is then packed in casks, in layers, separated with banana leaves, and this is done so as to retain moisture, and to prevent fermentation. If the paste be too dry water

The anatto kept moist.

is sometimes poured into the cask, for unless the anatto be kept moist it will deteriorate in value. The product, of course, contains only a proportion of the dye mixed with the powdered seeds, and it is, therefore, not nearly so valuable as

The advantage of preparing a pure dye.

the pure cake anatto. The purer the dye is sent to the markets, the higher will be the prices obtained for it ; and, unless a fine article be prepared, it is better to ship the dried seeds, from which the dye is extracted in England and the United States.

Turmeric. *Curcuma longa.*

The plant producing turmeric belongs to the ginger family, and it closely resembles ginger in its growth and habit as

Habitat.

well as in appearance. It is a native of some districts of India and of Ceylon, but it is now grown in all parts of the tropical world. The plant was introduced into Jamaica by Zachary Bayley Edwards in 1783, and it has become wild in many parts of that island, as well as in Dominica and other islands of the West Indies.

The dyes.

A beautiful yellow dye is obtained from the rhizome of the plant, but it is not now used very extensively as the colour is not of a stable nature. It is employed, however, on a comparatively large scale to give the yellow colour to var-

nishes. In some of the Polynesian islands the natives use the dye to paint their bodies in much the same way as the Caribs used the testa of the seeds of the roucou plant. In chemistry a solution of turmeric is employed as a test for the presence of alkalies—which change its yellow colour to a reddish brown. But turmeric paper is more frequently used than the solution. This is simply unsized paper steeped in a tincture of turmeric and dried by exposure to the air. When dry it is of a light yellow colour, which is turned to a deep brown in the presence of alkalies. Turmeric is sometimes used as a medicine, more especially in certain affections of the stomach—where its bitter tonic and aromatic stimulant action is sometimes followed by useful results. In Eastern countries the product is used extensively as a spice or condiment, and it is an ingredient in all good curry powders. In this country it is of greater importance as a colouring agent in confectionery and in medicine.

Its uses.

Turmeric paper.

Medicinal action.

Used as a spice.

The plant requires the same soil and climate as ginger. And, the method of propagation, and cultivation, and gathering and preparation of the crops is the same for both plants. It is unnecessary, therefore, to enter into all these particulars as they have been fully treated of under the head of ginger in Chapter IX.

Soil and climate.

Cultivation.

In Nepal, a country lying to the north of India, turmeric is planted after wheat as a rotation crop ; and, when a proper system of rotation is employed in the West Indies, the cultivation of turmeric may with advantage be undertaken on lands from which a heavy crop of maize or one or other of the tropical cereals has been reaped.

Cultivation in Nepal.

In commerce Turmeric occurs in three forms, known as fingers, bulbs and cut bulbs. Fingers are the longer and narrower rhizomes, bulbs are the shorter and thicker ones, and cut bulbs are simply the rhizomes cut into pieces before they are dried. For medicinal and chemical purposes the cut bulbs are best liked, and they should be of a yellow colour externally and of a deep orange internally.

Fingers, bulbs and cut bulbs.

Logwood. *Hæmatoxylon campechianum.*

Habitat.

The logwood tree is a native of Central America, and it found in great abundance in the lands bordering on the ba of Campeachy,—hence its botanical name. It was intr duced into Jamaica from Honduras by Dr. Barham, in 171 and later on it was carried to other parts of the West Indie In Jamaica and Dominica it has spread by self-sown see over large districts of the coastlands as well as some parts

Naturalized in the West Indies.

the interior. Dr. Macfadyen, in his flora of Jamaica, pu lished in 1837, says:—"Few plants have been so complete naturalized. It thrives in every situation, with the exce tion of the loftier mountains, and, with the Opoponax ar

The seeds.

Cashaw, occupies our plains." The seeds, being winge are often carried far away from the parent plant by tl wind, and to this fact is due the wide distribution of tl plant.

The dye.

Logwood is used in medicine as an astringent, but its pri cipal use is as a dye. It was introduced into Europe by tl Spaniards some time after the discovery of America b

History of the dye.

Columbus, and it was used in England as a dye in the reig of Queen Elizabeth. The dyers of those days, however, kne nothing about *mordants*—which are chemical substanc used to fix the colours in fabrics—and the result was that tl logwood dyes washed out from the cloths. The peopl therefore, became greatly prejudiced against logwood, a in the 23rd year of Elizabeth's reign an act of parliame was passed prohibiting its use and ordering it to be burne

Uses of the dye.

wherever it was found. This law was not repealed un nearly a century afterwards, by which time the dyers h learnt to fix the colours permanently. The chief use now- days of logwood is for dyeing woollen goods "on which produces, with various mordants, shades of blue from a lig lavender to a dense blue black according to the amount logwood used." It is used also by calico printers, clo dyers and hat makers, and the fine black silkiness of th

LOGWOOD PLANTATION, JAMAICA.

[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

CHIPPING LOGWOOD, JAMAICA.

"top-hats" is produced by logwood dye in combination with indigo and mordants. Besides blue and black, many other colours are produced by acting on a decoction of the wood with various chemicals and so the red logwood may be made to create nearly all the colours of the rainbow. The common black inks, too, are made from logwood, and it was used by unprincipled persons in making up unwholesome compounds sold as claret and port wines. Indeed, at one time it was a common saying in Dominica that some of the logwood exported from that island to the French colony of Martinique, returned in the form of claret!

Great variety of colours.

The wood formerly used to sophisticate wines.

The tree is a low spreading one rarely reaching to the height of forty feet, with a trunk at the most not more than eighteen inches in diameter, and usually ribbed longitudinally. The stem is frequently crooked, and the smaller branches are covered with a whitish bark, usually unarmed; but in hot, dry places the branches are spiny. The small yellow flowers are borne in lax axillary racemes; they are attractive to bees, and in Jamaica are a valuable source of honey.

Description of the tree.

SOIL AND CLIMATE.—Logwood will grow well on most soils except loose sands and heavy clays. It grows best, however, and produces finer heart-wood on moist, rich soils where there is an abundance of vegetable matter. The climate must be hot, but not arid; although the plant, when it has become firmly rooted in the ground, stands a drought very well. Morris states that the logwood grows in great abundance in the moist lands lying to the north and west of British Honduras, being found in immense thickets; and, in Hayti, the best wood comes from the interior.

The best soil.

Climate.

PROPAGATION.—The plant is propagated by seed, and seedlings may be raised in nursery beds in the usual way. In countries where the tree has become naturalised, young plants can be obtained in great numbers in the neighbourhood of old trees. The seedlings should be dug up

Nurseries.

Seedlings.

carefully during the rainy season, and at once planted in the places where they are to grow.

CULTIVATION.—Logwood can scarcely be said to be cultivated, for most of the blocks are cut from self-sown trees. But, waste lands, unsuitable for other cultivations, may with advantage be planted with logwood, and properly tended trees will give a finer product than those growing wild.

A suitable cultivation for waste lands.

A large demand for the best wood.

Logwood has always maintained its position notwithstanding the introduction of aniline dyes, and the trade has never entirely failed, as is the case with other vegetable dyes.

Distances.

Holes are to be prepared, as described in former chapters, at distances of fifteen feet—which will allow about two hundred trees to the acre—and the seedlings should be put out when the ground is thoroughly wet; and, if this be done, but few plants will be lost. An occasional weeding will cause the young trees to grow faster, or cattle may be folded in so as to eat down grass and weeds. All suckers and side shoots should be pruned off, and, whilst the plants are young, some of the lower branches may be sawn off close to the stem so as to produce trees with clean straight trunks which produce the best logs, and give less trouble in removing the sap wood.

Weeding.

Pruning.

Felling.

CUTTING THE LOGS.—At about the age of ten years the trees will be ready for felling, which is done by axe-men, who afterwards junk up the trunks into large logs or billets about three feet long. The sap wood, which is light and valueless, is then chipped off, and this is the most troublesome of all the operations. The heart-wood is very heavy and of a deep brownish-red colour; and it makes very pretty cabinet work, as it takes a high polish. When the logs arrive at the home markets they are usually cut into chips by powerful machinery, as the dyers are better able to manipulate the wood in this form. In places where logwood is cut on a large scale for export, it would pay much better to manufacture the chips at once and

The wood.

Chips.

pack them in closely pressed bales. For, if this were done, much waste would be prevented as the whole of the heart-wood, including the chippings, could be worked up, and thus add considerably to the quantity obtainable. How to increase the returns.

In Jamaica quite a large business has been established in digging and exporting logwood roots left in the ground when the trees were felled during the last twenty or thirty years. Some idea may be formed of the importance of log-wood as a dye when it is remembered that the imports into England alone are valued at more than a quarter of a million sterling for a single year. This figure now includes extract, the bulk of the imports of both wood and extract coming from the British West Indies. The English market.

INDIGO. *Indigofera:* various species.

THE blue substance called indigo is obtained from several species of *Indigofera*, and the cultivation of indigo plants and the preparation of the dye were practised in India from the earliest times. The dye was known to the Romans as *indicum*, and the distances it had to be brought in the days when such journeys were difficult and dangerous rendered it very costly, and caused its origin to be shrouded in mystery. An ancient dye.

Some of the early writers describe the dye as a mineral, whilst others supposed it to be a vegetable exudation mixed with mud. In the fifteenth century the Dutch brought the dye from the East in considerable quantities; but, as it interfered with the manufacture of woad—a blue dye obtained from *Isatis tinctoria*, a plant cultivated in European countries—the use of indigo was forbidden by several governments. In Germany, a law was passed in 1654 prohibiting the use of indigo and stigmatising it as devil's dye; and, in Nuremberg, the magistrates compelled the dyers to take an oath once a year not to use indigo. In France, from 1598 until 1737 the use of the dye was forbidden in order to protect the woad growers, so that it was not until about the middle of the last century that dyers were permitted to use what substances History of the dye. Woad. The devil's dye.

The former cultivation of indigo in the West Indies.

they liked. At one time indigo was cultivated to some extent in Jamaica and Dominica. The cultivation was given up, however, on account of the precariousness of the crops, and the unhealthiness caused by the effluvium resulting from the fermentation of the plants in the process of the manufacture of the dye.

Natal or Java indigo and other species.

Indigofera arrecta is known as the "Natal" or "Java indigo. It is a perennial usually grown as an annual height about 3 or 4 feet or more according to conditions o culture. The seed sometimes requires treatment to ensur germination, and the method usually practised in Behar— where this species is now the principal one grown—is t treat it with strong sulphuric acid (approx. 10 lbs. of aci to 40 lbs. of seed) for half an hour, then wash in clean col water two or three times, when, after drying it is read for sowing. *Indigofera tinctoria* is another good source o Indigo, formerly largely grown in India, but now almos superseded by *I. arrecta* and *I. sumatrana;* the sam general particulars might apply to all three plants, excep that the seed of *sumatrana* and *tinctoria* appears t germinate freely enough without any special treatment an in general these two plants seem to be better known.

Anil.

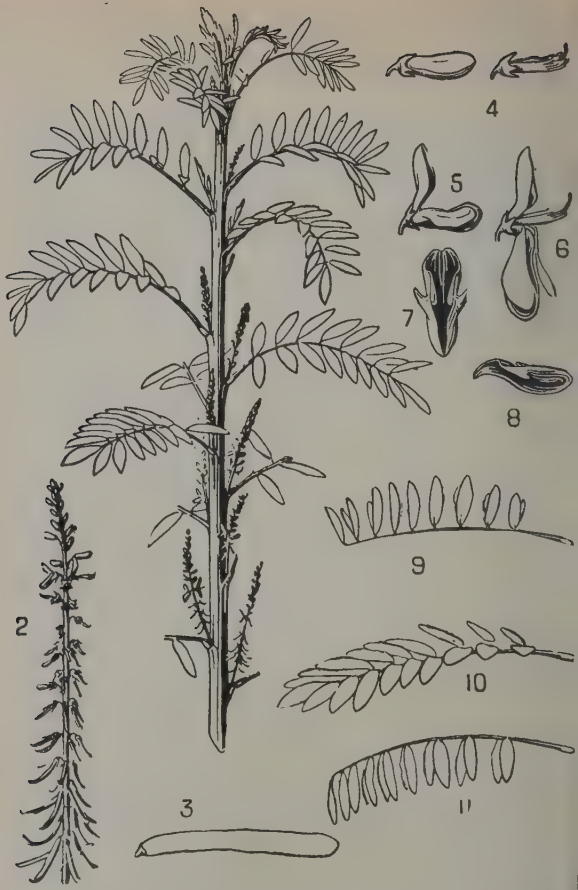
Indigofera suffruticosa, Mill. (*I. Anil*, Linn.) is also grown more especially in tropical America, where the Spanis name is "anil"; also in Burma, Indo-China and S. China and widely spread throughout the tropics, sometimes bein found as a common weed.

SOIL AND CLIMATE.—Indigo plants, and more especiall *I. Anil*—which is a troublesome weed in some parts of th West Indies—are hardy and will grow on most well-draine soils in a suitable climate. The best soil, however, for th profitable cultivation of indigo, is a rich loam with a ligh free subsoil that permits the running off of all surplus moi ture. The soil must not be too dry and sandy, nor too w and clayey, but a medium between these two. If the subso be wet, the plants will either die, or grow up sickly, and giv

The best soil.

INDIGO: BRINGING IN THE PLANT AND LOADING THE STEEPING-VAT, INDIA.

[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*



"JAVA" INDIGO.

1, A flowering branch. 2, A complete inflorescence. 3, A ripe pod. 4, A flower bud, showing the relative position of the anthers and stigma just as the pollen is liberated. 5, A fully-opened flower. 6, A sprung flower. 7, The keel seen from above, showing the projecting spurs and folds. 8, Half the keel seen sideways, showing the fold which keeps the young pod in place. 9, The position of the leaflets at midday. 10, A leaf in early morning. 11, The position of the leaflets at dusk.

[*From "The Improvement of Indigo in Bihar" (Bihar Planters, Association, Calcutta, 1914), by A. Howard and G. C. Howard.*

poor returns. Cultivation is confined to places where the temperature never falls below 60° Fahr., and where the atmosphere is not laden with moisture. The plant is a lowland one, and no attempt should be made to grow it systematically in the mountains.

CULTIVATION.—The spring is the best time for sowing, and the land should be well prepared before hand. Several ploughings should be done, and the subsoil should be broken up as much as possible. The surface soil is then to be brought to a fine tilth by careful harrowing ; and, in order to produce what is called a good "seed bed" the land may be lightly rolled afterwards. The seed, which should be as fresh as possible, is mixed with sand or ashes, and sown by means of a machine called a *drill* in lines distant about two feet from each other. The seed must not be sown broadcast, for if this were done weeding would be impossible, and the plants would therefore soon be choked by fast growing indigenous vegetation. In places where the drill cannot be used, the seed may be deposited in small shallow holes made with the hoe, at distances of from ten to fourteen inches apart in the lines. Or, as many seeds as can be taken up between the thumb and forefinger may be deposited in each hole and covered with about half an inch of earth. The quantity of seed used varies from ten to fifteen pounds for every acre ; and, on indigo plantations, a considerable number of the best plants are always left to produce seed pods for the next crop. Ten bushels of pods yield about a bushel of clean seed.

Preparation of the land.

Sowing the seed.

The quantity of seed required.

In favourable seasons the plants spring up in three or four days after sowing, and then they must be weeded by hand, all the weeds being carefully pulled up so as not to injure the seedlings. When the plants are a few inches high the hoe may be used, and three weedings will be necessary before the indigo is ready to cut, which should be when the flowers appear, and this will occur in about three months from the time of sowing the seeds. As March is the best month in the

Weeding.

The sowing season. Cutting.

West Indies for sowing indigo, the cutting operations will commence in June. The plants are usually cut down to within a few inches of the ground with sickles, and then tied up in bundles to be carried to the place where the indigo is manufactured. As exposure to the sun injures the cut plants, the operation should be begun and finished in the afternoon.

Rattoons.

After being cut down the plants will rattoon ; and, in favourable circumstances, as many as four cuttings have been obtained from the same roots in a year ; but this is unusual for the plants quickly deteriorate, and seed must be freshly sown every year.

Blights.

The indigo plant is liable to be attacked by many insect enemies, which in some instances so infest the leaves as to destroy the entire crop. Some species of caterpillars are extremely fond of the leaves, and when the plant is cultivated on the same soil in succeeding years the enemies increase greatly in numbers ; it has been advised, therefore, that fresh soil should be chosen every year.

Manures.

Indigo contains a considerable proportion of nitrogen, and thus when the same land is cropped often, manures rich in ammonia should be used. The refuse of the plants, after the indigo is extracted, is perhaps the best manure, and it makes an excellent fuel. Where the refuse cannot be returned to the soil, farm-yard manure with a top dressing of lime will answer the purpose very well.

MANUFACTURE OF THE DYE.—The substances which form indigo reside in the leaves, but the whole plant for the sake of convenience and economy is subjected to the process of fermentation and agitation by which the dye is manufactured.

How the dye is formed.

The fermentation of the plants under water causes the dye matters to be dissolved out ; and these, combining with the oxygen of the air, produce the blue colouring substance known as indigo.

The dye made experimentally.

On a small scale indigo may be made experimentally by infusing the leaves in hot water, when the dye will be deposited by allowing the infusion to stand exposed

to the air, and the process may be accelerated by occasional agitation of the fluid.

Vats. When manufactured on a large scale, however, large wooden vats, or stone cisterns, placed like steps, one higher than the other, are necessary. The upper cistern, usually called the *steeper*, sixteen feet square and two and a half feet deep, has a bottom sloping gradually towards the end from whence the contents are discharged into the second cistern by means of a cock inserted near to the bottom. The second cistern, called the *beater*, should be twelve feet square and four and a half feet deep, and these cisterns will be sufficient to manufacture the dye from plants growing on seven acres of land. Below the beater a third cistern may be placed into which the contents of the beater is run and allowed to stand for the dye to settle at the bottom. But, unless the operations be done on a large scale, the settling of the dye can take place in the second cistern, which should be furnished with several cocks, at different elevations, so as to allow the clear fluid above to drain off from the precipitated indigo.

Cisterns.

Manufacture of indigo. Bundles of freshly cut plants brought from the fields are put into the first cistern or vat in regulars layers until they reach to within ten inches of the top. Planks are then laid on the plants and wedged down by some mechanical contrivance, and water is run in so as to cover the plants to a depth of three or four inches. The water must be pure, clear river water giving the best results; and, as a large quantity is necessary, indigo cannot be manufactured with success in places where an abundant supply of water is unobtainable. A few hours after the water has been run into the cistern, fermentation will begin, and it should last from twelve to sixteen hours. When the leaves become of a pale colour, and the tops are tender, fermentation has gone far enough; for, if it be continued after this stage, putrefaction will set in and the dye will be destroyed. The water, which has dissolved out the soluble substances that become indigo after they have taken up oxygen, is of a light green colour, and it

Pure water essential.

Fermentation.

The refuse plants.

is run off by the cock to the second cistern. The refuse plants are then taken out of the first cistern, and either dried in the sun for fuel, or at once placed on the land for manure.

Noxious odours.

They have a noxious odour, due to the putrefying vegetable matter, and this accounts for the unhealthiness characteristic of indigo manufacture.

Beating.

The liquor, now being in the second cistern, is to be constantly agitated for a period of from one-and-a-half to three hours. The agitation prevents further fermentation, and by exposing successive layers of the liquor to the air, it enables the whole in time to become oxidised, and thus causes the formation of the insoluble blue dye. The liquor may be agitated by some mechanical contrivance, or by men going into the cistern and beating and churning the fluid with

The formation of the dye.

wooden paddles. As the agitation or beating goes on the green liquor becomes of a deeper colour and then gradually turns to a blue shade as the insoluble indigo forms in minute particles called the *grain*. Then a small quantity of clear lime water is added in order that it may combine with the carbonic acid formed during the process of fermentation, but this is not really necessary, and some planters prefer to

Lime water.

do without the lime water as it is said to harm the indigo. The beating having been concluded, the colouring matter is allowed to settle, and in two or three hours the indigo will have subsided to the bottom, and an amber coloured fluid will remain on top. This clear fluid is then to be drawn off by means of the cocks, the highest one being opened first, and after the liquid has ceased running from it, a lower one is to be opened, and so on until nothing is left in the cistern but the indigo which looks like a bluish black mud. This

Draining off the moisture.

mud-like stuff is then taken out and put into conical linen bags which are hung up so as to allow the surplus moisture to drain away. Afterwards the dye is taken out of the bags and put into shallow trays to dry in the shade. Before it is

Cakes.

completely dry, however, it is cut into small cakes and stamped with the plantation mark.

In India and other eastern countries the mud-like indigo, before drying, is boiled in copper vessels for at least two hours, and afterwards spread on cloths stretched over bamboo frames, in order that the moisture may drain away—which may take from twelve to fourteen hours. The indigo is then pressed, cut into cakes, stamped and dried for the market. Boiling the indigo.

Good commercial indigo should float on water and show a copper-like surface when rubbed. The trade in natural indigo has declined by reason of the advance in that of synthetic indigo, and it is probable that the demand will now be readily met by British India—at all times the chief source—where research work by experts under the authority of the Government of India has been carried out for some years in order to improve the situation for the planter and to preserve the industry from further degeneration. Commercial indigo. Natural *versus* synthetic indigo.

West African or Yoruba Indigo. *Lonchocarpus cyanescens.*

A climber 30 feet or so in height, common near rivers in West Africa. It is cultivated for local use in Nigeria, and the plant is then grown as a shrub by being cut down and pruned to about 7 or 8 feet in height. The leaves and young shoots contain a blue dye found by Perkin to be identical with that furnished by several species of *Indigofera;* but containing only 20 per cent. or so of indigotin, and in comparison with Indian or Java indigo—with up to 80 per cent. of indigotin—it is considered of poor quality. Although serviceable for local use it does not appear advisable to cultivate it for export. The dye is prepared from the leaves or young shoots, which by the local method are pounded in a mortar into a black pasty state; this is made into balls 4 or 5 inches in diameter, and dried. One ball to a gallon of water is used when dyeing; the cloth is immersed for four days, the dye being fixed with potash, a very permanent and fine deep blue being thus obtained. Description of plant. Preparation of Yoruba indigo.

GAMBIER (*Uncaria Gambier*) PLANTED AS A CROP WITH OIL-PALMS (*Elaeis guineensis*).
The palm on the right is one year old.
[*From Malayan Agric. Journ., Sept.-Oct. 1927.*

COCHINEAL. *Opuntia* (*Nopalea*) *coccinellifera.*

This consists of insects (*Coccus cacti*) fed chiefly on *Nopalea coccinellifera;* cultivated in the Canary Islands, Mexico, Guatemala, Brazil, Java, &c.; introduced to Algeria, Australia and India for the rich crimson dye; used in the preparation of artists' colours. The colouring matter is "carminic acid." The dye was formerly of considerable importance, but since the coal-tar colours came into general use cochineal as a dye-stuff has become of only minor importance. Trade sources. Dye of minor importance.

The insects are collected in the dry season, being brushed off into baskets or similar receptacles; a number of the insects are left on the plant to keep up the stock. The insects are killed with boiling water or enclosed in linen bags placed in ovens. The plantations are sometimes called "Nopaleries."

Of the dye-plants, it is singular that the few that have survived the introduction of aniline dyes are capable of production in the tropics—logwood, indigo, anatto and cochineal (fed on plants of *Nopalea*) are still imported; but their inclusion here is not a recommendation to cultivate them, except under the most approved marketable conditions, and the advisability of development on a commercial scale must be left entirely to local considerations. At the best it may be found desirable to treat them only as catch-crops or as a convenience for local use. Dye-plants *versus* aniline dyes.

The tanning materials of commercial value that are suitable for cultivation are very limited, and still more so are those that are worth cultivating in the tropics. At the outset it is desirable to state that both dyes and tans, however good they may be in quality, are not acceptable to dyers and tanners unless large and continuous quantities can be assured. Tans.

GAMBIER: BOTANICAL FIGURE ILLUSTRATING LEAVES FROM WHICH THE TANNIN IS EXTRACTED.

[*From "Medicinal Plants," by Drs. Bentley & Trimen.*

GAMBIER. *Uncaria Gambier.*

Perhaps the most important tanning material suitable for cultivation is that of "gambier," also known as "pale catechu," "cubical cutch," "terra japonica," &c.

A scandent shrub or bush under cultivation, 8 to 10 feet high, native of the Malay Peninsula where it is largely cultivated—grown for the leaves. Description.

May be propagated by seed or cuttings, the latter for preference; planted out when about 9 to 12 inches high at distances of 9 to 12 feet apart. They begin to yield small crops of leaves in a year's time and more after about two years, when from two to four harvests of leaves a year may be obtained for upwards of twenty to thirty years. A rich and well-drained loamy soil, a good and regular rainfall, and a due proportion of sunshine are the main requirements, Careful weeding and good cultivation, manuring, and occasional topping of the plants to 6 feet or so, are essential conditions to keep the plantation up to standard. Propagation.

The plant is sometimes advised as a catch-crop in plantations where plenty of light and space are available, as, for instance, with pepper (*Piper nigrum*). Rubber and palm-oil plantations might grow it with advantage, especially during the earlier years, while the trees are young. Advised as a catch-crop.

The preparation of the catechu is comparatively simple. It consists briefly in boiling the fresh leaves and young shoots in water for about an hour and reboiling the juice until it thickens to a syrupy consistence, stirring being maintained meanwhile. The extract is then run off, cooled and set or nearly solidified by further stirring or kneading, dried until quite firm and made up into the usual commercial forms in blocks or cut and pressed into cakes; the fracture of these is somewhat earthy and in general appearance they resemble dried clay. A good yield is about 5 ozs. per plant per annum or about 168 lbs. per acre. At the present time (July 1926) this product for tanning is in good repute, Preparation of the tanning extract. Yield and trade sources.

for it runs into some thousands of tons per annum. Our supplies come chiefly from Sumatra and Malaya, from whence upwards of 6,000 tons came in 1925, valued at about £300,000. The fact that the extract is also used medicinally in India and other Eastern countries, and also as a masticatory—for chewing with "betle-pepper" (*Piper Betle*) and lime—may have the effect of reducing the exports from a particular country. It is also of value as a dye.

Divi-Divi. *Cæsalpinia coriaria.*

Description. A small, glabrous, unarmed tree; native of Central and, South America; cultivated in Australia, Java, India and East Africa. The pods are of importance for tanning purposes; they yield from 30 to 50 per cent. of tannin. The tree may be propagated by seed, which may be sown in bamboo pots or in nursery beds and transplanted to permanent places when about five or six months old, from Cultivation. 10 to 15 feet, later thinned out to 30 feet apart. Good soil—though the tree will grow on comparatively poor soil —moderate rainfall and careful pruning are essential. The trees begin to bear in from three to four years after transplanting and yield about 5 lbs. of pods per tree, the yield Yield and trade sources. continuing in profitable quantities for about twenty-five years, and from 80 to 100 lbs. of pods per tree is an average yield at maturity, or up to 6 tons of pods, according to the number of trees per acre in the plantation.

In preparation for the markets the seeds should be removed and the pods carefully dried and graded before shipment. Our principal supplies come from Curaçao, Venezuela, Colombia and India to the extent of several thousand tons per annum.

Wattle Bark or Mimosa Bark. *Acacia mollissima.*

Cultivation. A tree native of Australia; but the cultivation has been very successful on a commercial scale in Natal, from whence we get our chief supplies; extending to New Zealand,

Hawaii, California, East Tropical Africa—more particularly the hill regions. The cultivation in general is comparatively easy. It is recommended to raise plants by sowing the seeds in bamboo pots; planting out in the plantation when large enough to handle, or say about six months or so old, at distances the same as for divi-divi. Almost any soil, provided it is deep and well drained, is suitable. Bark may be collected after about five to eight years, when about 28 lbs. per tree may be estimated, and when the trees are fully grown upwards of 112 lbs. or more may be expected. It may be found more profitable at times to ship the extract; though both this and the bark are acceptable in the trade—upwards of 20,000 tons, value £180,000 approximately, being imported annually from Natal and other countries. Extract.

Other wattle barks might be mentioned, but it may be open to question whether any of them should be considered here, being perhaps more suitable subjects—as the timber is also valuable—for cultivation on forestry principles.

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CHAPTER XIV

TROPICAL CEREALS

MAIZE. *Zea Mays*

Habitat.

Maize, or as it is often called *Indian corn*, is a native of tropical America, where it was cultivated by the inhabitants from the earliest known times. In extra tropical regions it grows with great luxuriance in the summer time, and the early settlers in the United States finding the grain cultivated by the aboriginal Indians, called it Indian corn. Now-a-days maize is grown in enormous quantities in the States and the term *corn* has been universally applied to it there other cereals being known as *grain*. The Spanish discoverers of America found maize extensively used as food by the Caribs, and other inhabitants of the West Indies. The grains of corn were ground into meal by these ancient West Indians with stone mullers formed into beautiful symmetrical shapes and the author had some very fine specimens of these mullers which were found with other Carib stone implements in the Islands of Dominica, St. Kitts and Nevis. Even now maize is the staple food of the Indians of Central America who make its flour into thin cakes, called *tortillas*, which are baked on griddles. Indian corn prepared in various ways forms a very important part of the food of the people in the United States, where the area under this crop runs into millions of acres, and as a home source of the grain it is now perhaps only exceeded by the Argentine.

Origin of the name.

Used by the Caribs.

Stone implements.

A staple food.

MAIZE PLANT IN THE FIELD.

[*From "The Corn Crops," by E. G. Montgomery.*

Extensive cultivation of maize.

Other important trade sources are Roumania, Canada, British India, British West Africa, South Africa, Kenya (British East Africa), &c., and no other cereal except rice is cultivated on the same extensive scale in the tropics.

The many uses of the plant.

Maize being rich in nutritious matters, it is used all over the world as food both for man and animals.

The grain as a food may be used green as a vegetable, or as the basis of various patent foods—"Cornflour," "Cornflakes," etc. Other manufactured products include glucose,

Chemical composition.

starch, meal, oil and a rubber substitute. It is an important source of alcohol—yielding about 2½ gallons on the basis of a starch content of 64 per cent.—and acetone. All parts of the plant can be used for feeding stock (see page 460.) Cellulose is manufactured from the stalk, from which fine quality paper can be made. The pith of the stalk is recommended as a substitute for coco-nut fibre for purposes such as lining the hulls of ships and making explosives. The parts (air-dried) above ground have been estimated to consist of: grain 38·8, stalks 29·3, blades 9·8, husks 11·1, tassels (male flower panicles) 1·3, and cobs 9·7 per cent.[1]

Description of the plant.

Maize is a monœcious cane-like grass growing to a height of from five to ten feet, or even higher. The male or staminate flowers are borne at the summit of the plant in a loose

The flowers.

feathery panicle, and the female or pistillate flowers occur in dense spikes springing from the axils of the leaves, and enveloped by sheaths or spathes, the long pink styles hanging out like silken tassels. The number of spikes of female flowers varies according to the vigour of the plants; as many as seven have been found on the same plant;

The fruit.

but usually from two to five are met with. When fertilisation has taken place, the female inflorescence becomes what is known as the *ear* of corn. The seeds are arranged in rows upon a fibrous core called the *cob*, and the whole is embraced by the spathes which are sometimes called the *husks*.

[1] Duggar, *seq.*, p. 74.

MAIZE COBS.

The six principal types of corn—"Pod Corn"; "Pop Corn"; "Flint Corn"; "Dent Corn"; "Soft Corn;" "Sweet Corn."

[*From "The Corn Crops," by E. G. Montgomery.*

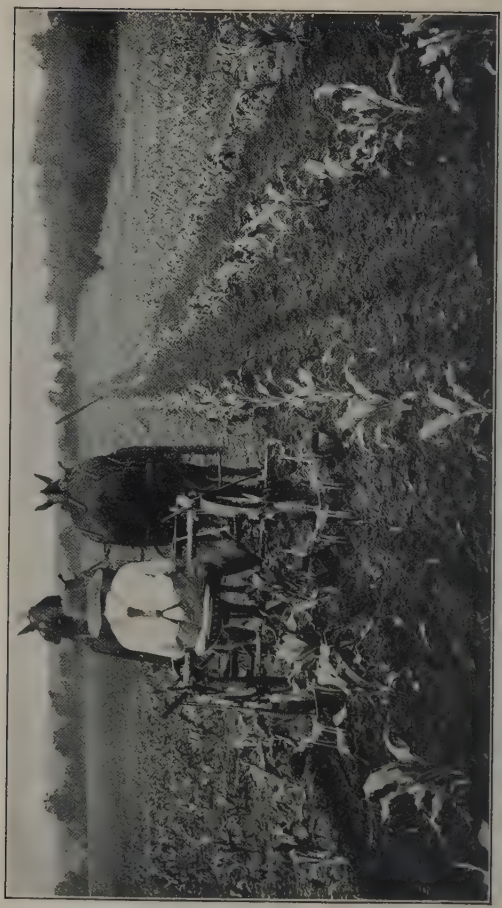
MAIZE COBS.

Showing "Sandford White Flint," the longest type of cultivated corn (four centre cobs), with typical cobs of "Dent" (right) and "Flint" (left) for comparison.

[*From "The Corn Crops," by E. G. Montgomery.*

Long continued cultivation in different climates and soils, and cross fertilisation of separate kinds, have produced innumerable varieties of maize, suited to the various conditions under which the plant is grown. The varieties are distinguished chiefly by the characters of the seed; in colour, white, red, and yellow; in number of rows of seeds on the cob, eight, ten, twelve, or twenty-four; and shape. There are so many varieties under cultivation (upwards of one thousand) that it is not possible to enumerate them here, but broadly those grown for the grain are divided into (1) "Flint Corns," including "La Plata," "Argentina"—largely grown in the Argentine—and those grown in South Europe, &c., the variety "Cinquantino" (five-sided) or "Yellow Flint," suitable for feeding parrots, pigeons and game birds, sometimes seen in the London market, shipped from the Danube. (2) "Dent Corns" (indented at the apex), commonly cultivated in the United States for export, one of the best being "Yellow Dent," the variety mostly grown there as a source of industrial alcohol, and accordingly often called "Distillers' Corn." "Hickory King" and "Hickory Horsetooth" are popular forms widely cultivated. (3) "Flour" or "Soft Corns," suitable for use as meal or as a vegetable, but, being readily affected by weevil, are not recommended for export. (4) "Sugar" or "Sweet Corns," the best for use as a green vegetable and for canning, for which purpose they are commonly grown. (5) "Pop Corns—so called from the fact that when roasted the grains burst or "pop" and expose the white central content—largely used in the United States as a breakfast food and for making into sweetmeats. Improvements by selection and by hybridization are constantly being made in many parts of the agricultural world. Varieties.

SOIL.—Maize grows well in widely different soils. The best soil is a sandy loam such as is found on alluvial flats by the banks of rivers, and the loams formed by the disintegration of volcanic rocks in many parts of the West Indies are admirably adapted to the cultivation. Clays and cold wet lands are to be avoided, for maize requires a well-drained soil. The best soil. Drainage necessary.



FIELD OF YOUNG PLANTS OF MAIZE UNDER CULTIVATION.
[*From "The Corn Crops," by E. G. Montgomery.*

CLIMATE.—The plant will thrive and give large returns in widely different climates. "The warmest regions of the "torrid zone produce maize in abundance, where three crops "can be taken in a season, while the short summers of Canada "have a variety adapted to them." In the tropics the plant grows from the shore to a height of more than 9,000 feet above the sea level. The climatic conditions are the same as those for sorghum except that maize requires more moisture, and in general may be regarded as being much the same as those required for cotton, that is, rainfall of about 50–80 inches, dry weather and clear skies for harvesting. Elevation.

CULTIVATION.—The land should be well ploughed up, and the subsoil turned over to a depth of seven inches. Then the land should be harrowed so as to pulverise the soil as much as possible, for the better the tilth the greater will be the returns. The land being prepared, it may advantageously be marked out in squares of three feet by means of a light plough, the furrows being first run one way and then cross furrows being run at right angles to them. At the points where the furrows cross each other from four to six seeds should be sown at a depth of two inches. Seed may also be sown at distances of about three feet, in rows four to five feet apart, for convenience in cultivating by the horse machine as illustrated on page 404, and to allow space for a row of cow-peas or green manure crop. Seedling plants may also be raised in nurseries and transferred to the fields when they are five or six inches high, for they bear transplanting very well. As soon as the young corn is growing in the field, a top dressing of wood ashes, or lime, or superphosphate should be applied, and each plant earthed up so as to provide soil for the growth of the roots which spring from the lower part of the stem. No more than four plants should be allowed to grow in each hill; so that, if all the six seeds have germinated, the two weakest seedlings should be pulled up. The land must be kept free of weeds, and the

Importance of good tillage.

Furrows.

Sowing the seed.[1]

Distances.

Nurseries.

Moulding up the plants.

Weeding.

[1] See also pp. 48 and 50 for particulars of a machine for sowing the seed.

earth should be stirred up with the hoe whilst the weeding is in progress. The plants send up suckers from the roots near the stem, and these suckers should be nipped off or otherwise they will injure the crops; the suckering should be done if possible before the plants are earthed up. When fertilisation has been accomplished the tops of the plants may be cut off so as to enable the ears to come to maturity earlier by exposing them to the light and air; and as the seeds harden, the leaves may be stripped off the stem. These tops and leaves make excellent fodder for cattle.

Nipping off the suckers.

Fodder.

CROPS.—When the seeds have become perfectly hard, and the spathes have turned white, the crops may be gathered. This is done by simply detaching the ears and drying them afterwards; or, the stalk may be cut close to the ground, and stacked up for some days in the field so as to dry in the sun. Of course dry weather must be chosen for these operations. If left in the ear the corn will remain in good condition for long periods. The best way is to pull back the husks, and to tie two ears together by knotting the ends of the husks. They may then be hung up on sticks in houses or barns, in the same way as tobacco is in the curing house. (See Chapter X.) When the maize is stripped off the cob, it is known as *shelled corn*. If the stripping be done by hand it is a very tedious and laborious operation; but machines have been invented for shelling the corn, and as they are inexpensive and work quickly they soon pay for themselves by the saving in time and labour they effect. The cobs, after the corn has been separated, make excellent fuel; and the husks are used in America for stuffing beds instead of straw, for they are much softer and do not crumble into dust. The shelled corn should be very carefully dried, if it be kept for any length of time, as it is prone to mildew. In the United States maize is preserved by being dried in a kiln—the heat not being allowed to rise above 212° Fahr. In this

Harvesting.

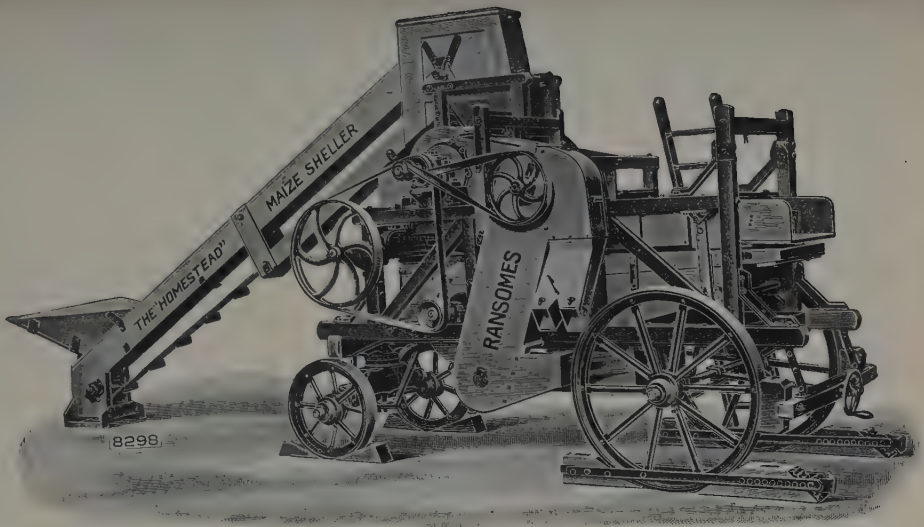
Corn in the ear.

Drying the corn.

Corn shellers (see pp. 407–9).

Uses of the cobs and husks.

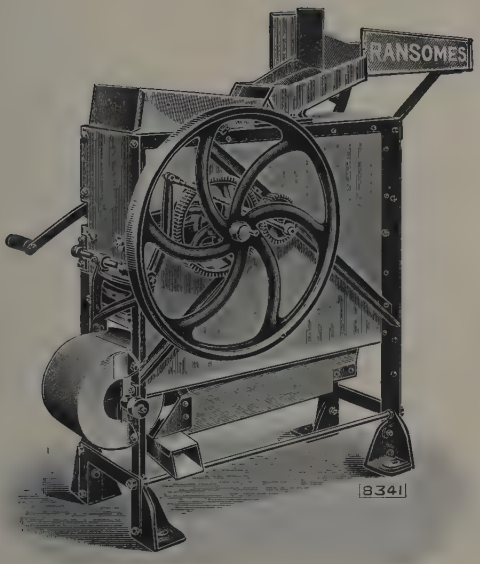
Kiln drying.



"MAIZE" OR "MEALIE" SHELLER ("HOMESTEAD").

Designed to husk and shell maize in one operation; capable of dealing with 150 to 250 bags (of 200 lbs. each) of maize per day of 10 working hours; driven by a small portable steam engine. May also be adapted to treat "Kafir-corn" or sorghum. The machine is portable, and can be drawn by 4 or 6 oxen.

A MAIZE SHELLING OUTFIT AT WORK.



HAND POWER MAIZE SHELLER ("RHINO").

Output approx. five 200 lb. bags per hour, or may be worked by engine power, when from six to seven bags (of 200 lb. each) per hour can be dealt with. Designed for shelling only—all cobs must be husked before feeding into the machine.

way the germ is destroyed, and all surplus moisture is driven off.

Returns. In the tropics maize will give a return in from two to three months, and thus several crops may be taken off the same ground during the year. But unless the land be

Manuring. very rich, high manuring will be necessary, and no crop, perhaps, shows better results for expenditure in manures than maize. The returns vary much, according to soil, cli-

Heavy Crops. mate and cultivation. From fifty to eighty bushels should be obtained from good land, but much heavier crops are often reaped, whilst in general a good average yield may be estimated at from thirty to forty bushels of grain per acre.

RICE. *Oryza sativa.*

The enormous consumption of rice. Of all the grain crops, rice supplies food for the principal number of the human races, especially in India, China, Japan and other Asiatic countries. The chief areas of production and trade sources are British India, Siam, Java, United States, Japan, China, &c., and "Patna," "Rangoon," "Siam Garden," "Java," "Carolina," "Japan," and "Japanese Unpolished" are important commercial descriptions.

Habitat. The plant is supposed to be a native of the warmer regions of Asia; but, as it has been found growing wild in several places in South America, it is thought by some botanists to be also of American origin. The cultivation, formerly confined to the East, has now spread over most of the tropical

Cultivation in America. and sub-tropical countries of the world. In the Southern States of America the cultivation of rice began about the year 1700, seed having been introduced by the captain of a vessel that had come from Madagascar; and, before long

Carolina rice. the Carolina rice became the finest in the world. Atwood, in 1791, writes, "Rice grows extremely well in Dominica," and he states that it was introduced by the American re-

Former cultivation in the West Indies. fugees, and that it yielded crops "in great perfection." At the beginning of this century Lunan wrote that it "thrives well in many parts of Jamaica," and he expresses his regret

that the cultivation was almost altogether neglected in that island. It is now being revived.

Description of the plant.

Rice is an annual grass, with a round jointed stem, reaching to a height of from one foot to six feet. The seed is borne at the termination of the stem, and it is protected by a rough yellow husk. The term *paddy* is applied to the grain in the husk, and in this condition it keeps sound for several years.

Varieties.

There are very many varieties of the plant, under cultivation in different countries, but the two principal kinds are the common or aquatic rice, and the mountain rice. The former can be grown only in land that is hot and marshy, the latter will thrive on ordinary soil at elevations of even 6,000 feet above the sea.

Common rice and mountain rice.

Of the thousand or more varieties, it is advisable to select those that meet marketable conditions, suggested by the trade names quoted above and according to period of maturity. In the Gulf region of the United States, "Honduras,"—with long grain, "Blue Rose"—medium grain, and "Wataribune" (Japanese)—seed short and rounded, all maturing in from about 130 to 140 days, are largely grown.

Common Rice.

The best soil.

Soil and Climate.—The best soil for rice is a sandy loam overlying a substratum of clay, the loam forms a bed for the easy penetration of the roots of the plant, and the clay prevents the draining away of the water, without which common rice cannot be cultivated. It follows from these facts, therefore, that pure clays and loose sands are unsuited to the growth of the plant. The climate must be a hot one; and, as rice delights in the sun, all shade is harmful. The great rice districts of the East are the hot, humid lowlands along the banks and estuaries of the large rivers.

Climate.

Irrigation.

Preparation of the Land.—In places where the soil is not naturally wet irrigation is absolutely necessary. In Eastern countries, when water cannot be turned on to

the land from streams and rivers, owing to their low l
it is pumped up by various devices, some of them being
rude and requiring much labour. In Louisiana, where a
half the American crop is grown, the water is obtained
pumping, mostly from streams and wells, distributed
canals. In general the flooding and subsequent drain

A single Spikelet of Flower

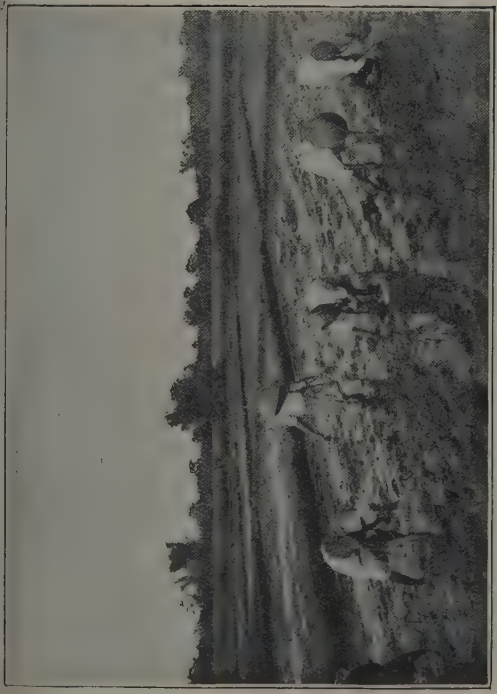
RICE. *Oryza sativa.*

of the fields requires considerable engineering skill to regula
the depth of water and the right periods for drying off the lar

Fields and banks.

The surface of the land is marked out and levelled in
small fields, which are surrounded by banks two feet high
keep in the water. On sloping land terraces are formed, a
these are also divided into compartments by earthen wall

The banks are pierced in convenient places for the purpo



TRANSPLANTING RICE.

[*From "Rice," by E. B. Copeland.*

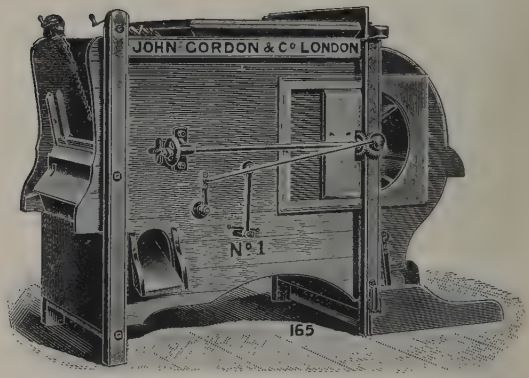
NEWLY TRANSPLANTED PADDY.

[From "Rice," by E. B. Copeland

of letting in the water and allowing it to run out again. On the terraces the water in the upper fields being allowed after a time to flow over the lower ones. When the banks have been built up, the land inside is weeded and ploughed, or turned over with the spade or hoe. The water is then let in, and the soil is worked up into a puddle in which state it retains the water better. Terraces. Puddling the land.

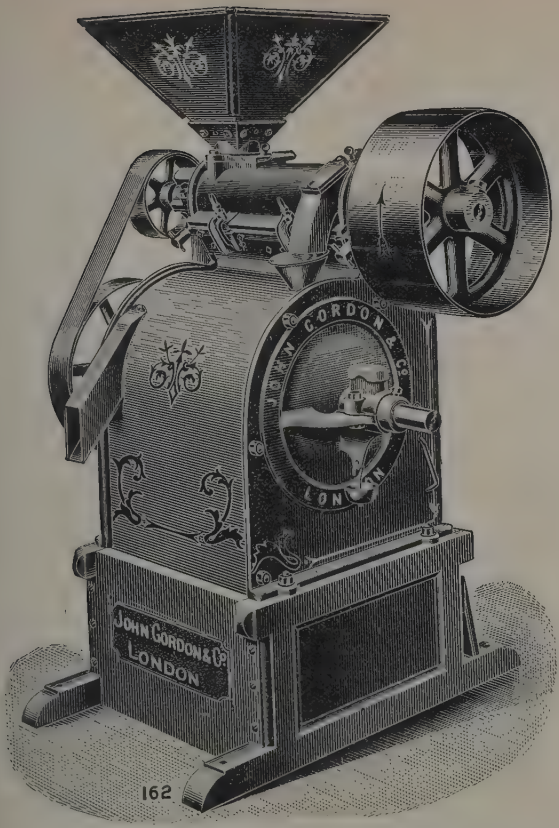
CULTIVATION.—The land being prepared, the seed which should be steeped in water for twenty-four hours is sown in a corner of the field so as to form a nursery. When the young plants spring up, it is usual to water them with a solution of lime so as to prevent the depredations of insects. In China this sprinkling with lime water is considered to be a very important operation, and it is never neglected. When the seedlings are seven to eight inches high, they are transplanted quickly so as to prevent their roots being exposed for any length of time. They may be planted singly or in bunches of two or three at distances of from six to nine inches from each other, either irregularly over the fields or in lines. Some cultivators sow the seed broadcast and then thin the plants out if they grow up too thickly—the surplus seedlings when pulled out serving to supply vacant patches. It is considered, however, that the nursery system is the best, and that it yields larger returns. About a bushel and a half of paddy is usually sufficient to sow an acre of land. In the early stage of growth the rice will have to be kept free of weeds, and as the plants are close together the weeding will have to be done by hand. The weeds can be buried in the mud, and in this way they will nourish the soil, as they will soon decay. The fields are kept flooded with water until the flowers appear, and then they may be irrigated at intervals of three or four days in dry weather. When the heads of grain are well formed, the water should be shut off so as to hasten the ripening process. Nurseries. Lime water. Transplanting. Quantity of seed required to sow an acre of land. [1] Weeding. Shutting off the water.

[1] Duggar (*seq.*) records "from less than 90 lbs. in Louisiana to a maximum of 150 lbs. an acre in California."



RICE CLEANER.

This machine consists of a winnower combined with a series of sieves. It is used for removing grit and other substances from the "paddy" before shelling: and it is also used for removing the husk from shelled rice. It can easily be worked by hand power. Made in five sizes, the largest capable of dealing with 5 tons per day.



RICE SHELLER AND POLISHER.

In this machine the rice is shelled and polished in one operation. The upper cylinder is fitted with a rotating ribbed roller, and an adjustable hulling blade, between which the "paddy" is passed, removing the outer husk: the shelled rice now passes to the lower drum, which is fitted with a rotating cylinder covered with leather, and in its passage the rice is cleaned and polished and finally delivered in a condition fit for immediate use. Power required, from 8 to 10 h.p. engine. Capacity 350 to 500 lbs. per hour. Smaller machines are made for 2 h.p. engine, and capacity 70 to 80 lbs. per hour.

CROPS.—Harvesting usually commences within five or six months of the time of sowing; and thus, as by irrigation the planter is independent of the rain, two crops may be got in the year. May and November are the sowing seasons, and October and April the times of harvest. When the grain turns yellow, it is ready for the sickle; the whole plant is not mowed down, but the head is cut off with about a foot length of the stalk. The crop is tied into small sheaves; and, after some exposure to the sun, the sheaves are carried to the houses or sheds where the grain is threshed out. The threshing is usually performed in Eastern countries by bullocks or horses, the animals being made to walk in a circle, and the heads of rice thrown under their feet are soon separated into grain and straw. Threshing may also be done expeditiously by means of a flail. The paddy, after being threshed, is separated from the straw and winnowed, and it may then be kept in good condition for a very long time. To prepare the clean rice from the paddy a hulling operation is necessary. On a small scale this may be done by rubbing the grain between flat stones and blowing the husks away, but on a large scale a mill or a hulling machine will be necessary. The removal of the outer husk of the grain is the first operation in the milling process, but cleaning the raw grain in the first instance may be desirable, and "paddy cleaning separators" may be obtained for this purpose. After hulling, the rice is winnowed and for food may also be polished, when it is ready for the market. In the milling it it found that about 40 parts paddy give 25 parts of white rice, 5 parts polishings and 10 parts of husk.

Harvest seasons.

Threshing.

Winnowing

Hulling.

Machinery (see pp. 416–18).

Returns.

The yield of rice from an acre of land varies, of course, according to the richness of the soil, but with good land the returns should be about fifty bushels. In Bengal the rice is divided into three qualities. The first and finest kind is called *table rice* and this is mostly exported to Europe; the second quality is called *ballam rice*, and the commonest, which is mostly consumed by the natives, is known as *moonghy rice*.

The three kinds of rice.

When rice is cultivated on the same land for successive years manuring is necessary, compost and animal manures giving the best results. The Chinese, who are very skilful cultivators, manure their fields with all kinds of animal and other refuse, in fact they destroy nothing that can in any way add to the fertility of the soil. Decaying vegetable matter to ensure a good supply of humus is of importance, and ploughing in of the stubble is recommended. Artificial manures may be used, but require care in order to avoid an overgrowth of stem and leaves. Sulphate of ammonia applied at the rate of about 70 lbs. per acre has been recommended in the Gulf region of the United States.

Manuring.

High cultivation in China.

Green manures and sulphate of ammonia recommended.

Mountain Rice.

Upland or mountain rice, though producing a similar grain to the common or aquatic kind, differs greatly in its habit and cultivation. It thrives at elevations of from 3,000 to 6,000 feet above the sea in the mountainous regions of northern India ; and it will grow in temperate climates. although it will not yield crops of grain in such latitudes, Irrigation is not practical in its cultivation, the treatment of the plant being similar to that of the common cereals It makes excellent fodder, and it will pay to grow as a green crop, two cuttings being obtainable during the year. It may be cut and made into hay ; sheep, cattle, and horses being extremely fond of it. The crops yielded are larger than those of common rice, but only one harvest can be gathered in the year. Aquatic rice is said to yield from twenty-five up to eighty-fold of grain, whilst mountain rice returns a hundred-fold and even a hundred and twenty-fold.

Climate.

Fodder.

Large crops.

Cultivation.—The land is ploughed and manured in March, and in May it is again ploughed and then harrowed, and the seed is sown in drills, or it may be sowed broadcast. Another plan is to make small holes with the finger at a span's distance from each other, and then to drop a few seeds in each hole, and cover them lightly with mould. The

Sowing the seed.

seeds spring up in about a week from the time of sowing and when the plants are a few inches high the ground is to be weeded. Another weeding may be undertaken before the rice grow too high, and then it may be left to take care of itself until the crops are gathered, which will be about September.

Weeding.

Harvesting.

CROPS.—The harvesting and other operations connected with the crops of upland rice are similar in every respect to those already described under the head of common rice, except that in gathering the crops, it is usual to cut off the ears without allowing any length of straw to be attached to them, and as the plant does not grow higher than three feet this is the easiest way of reaping.

GUINEA CORN, GREAT MILLET OR SORGHUM.

Under these names there are several plants often classified under *Andropogon Sorghum* var. *vulgaris* (*Sorghum vulgare* and *Holcus Sorghum* are synonyms), the very diverse characters of which have admitted of separation into the species of *Sorghum* named below. They include the distinct cultural groups recognised in the United States, India and South Africa.

Cultural groups.

(1) *Sorghum Caffrorum*, Beauv., generally known as "Kafir-corn," an annual about 6 feet high commonly grown in South Africa; introduced into the United States, where a variety—"Black-hull Kafir"—with nearly white grains is one of the principal sorghums grown for the grain. (2) *S. caudatum*, Stapf.; culms about 14 feet high, grown in various parts of tropical Africa. There are several varieties, but the best known is that of "Feterita," perhaps the most important food-grain of the Sudan; remarkable for the whiteness of its grain and flour of excellent quality, which has been recommended for making bread in Italy. (3) *S. cernuum*, Host., an annual, stems 10 to 14 feet high; grown in West Africa, North Africa, and introduced into the

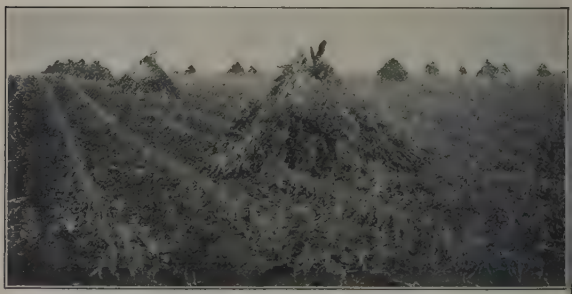
Species and Varieties of *Sorghum*.

THE PRINCIPAL TYPES OF SORGHUM.

1, Amber. 2, Orange. 3, Sumac. 4, Red Kafir. 5, Pink Kafir. 6, Blackhull Kafir. 7, Shallu. 8, Milo. 9, White Durra. 10, Brown Durra. 11, Brown Kowliang. 12, Standard Broom-corn. 13, Dwarf Broom-corn.

[*From "The Corn Crops," by E. G. Montgomery.*

PLOT OF "MILO" WITH ERECT HEADS.



FIELD OF "WHITE KAFIR-CORN" IN SHOCK.

[From "The Corn Crops," by E. G. Montgomery.

"WHITE KAFIR-CORN" HEAD.

"YELLOW MILO"—HEAD UPRIGHT.
(See Fig. 8, p. 421 for "Pendent Milo.")
[*From "The Corn Crops," by E. G. Montgomery.*

West Indies, &c. This has a fine white grain which is a staple food in West Africa and in all countries where grown. In Nigeria it is known as "mazaggua" or "maskwari" or "dry season corn." (4) *S. Durra*, Stapf.; culms 14 feet and upwards in height; cultivated in the Sudan, Egypt, Arabia, India, United States, &c.; the grain being an important food-crop in all countries where it is grown; reported to be one of the best for grain production. In Egypt it is known as "durra," and is also grouped under this name in the United States, where several varieties are grown, including "White," "Brown" and "Milo." "Jerusalem corn" and "Egyptian corn" are common names. (5) *S. Roxburghii*, Stapf.; culms 5 to 8 feet high; a native of India, where it is called "Shallu"; cultivated in East Africa, United States, &c., but said to be not so dependable as a grain-crop under dry-land conditions without irrigation as either "Kafir," "Feterita" or "Milo." "Egyptian rice" or "wheat," "Californian wheat" and "California golden sorghum" are names applied to this plant.

SOIL AND CLIMATE.—The plant will grow and yield a crop in nearly every soil, but the soil best suited to the cultivation is a rich light sandy loam, well drained and not too moist. The climate should be a dry one; and, in order to obtain large crops, the lowest temperature should not fall much below 60° Fahr. Guinea corn will stand drought remarkably well, so that the hot and dry lowland regions of most tropical countries are peculiarly adapted to the growth of this valuable cereal.

Guinea corn stands drought.

CULTIVATION.—The land having been ploughed and harrowed, the seed is sown at the rate of about 5 lbs. per acre in furrows, or drilled in by means of one of the useful seed drills now made by the manufacturers of agricultural implements. The lines or furrows for the seed should be from three to three and a half feet apart, and the plants should be thinned out after they have sprouted, so that the seedlings

Planting machine (see pp. 48 and 50).

Thinning out of seedlings required.

may be about ten to twelve inches apart in the rows. As soon as the corn is a few inches high the field must be thoroughly weeded, and a second weeding may be necessary later on, or a light plough or cultivator may be run between the rows so as to turn up the soil and destroy the weeds. Very soon the plants will cover the land by their luxuriant foliage, which grows with great rapidity.

Harvesting. CROPS.—The best season for sowing is at the end of the rains, and crops may be reaped four or five months later; although when grown under favourable conditions, returns have been got in three months. When the corn has arrived at maturity, it is harvested by cutting off the ears near to the top of the stem, and then carrying them in baskets to the house or shed. The ears are kept in heaps for a few days, and afterwards they are spread on the floor of the building, and the grain is threshed out by means of a flail. In some parts of the East, millet, like rice, is threshed by bullocks being made to tread on it.

Threshing.

Primitive systems in the East.

Returns. The crops of Guinea corn got from an acre of land vary considerably; forty bushels, however, may be considered as a good average return. But double that quantity is mentioned sometimes as being a not unusual crop from good soil. In India and Burma, where 24,000,000 acres are roughly calculated under cultivation, the low average of 500 lbs. per acre is estimated, and in the United States from 3,000,000 acres 25 to 30 bushels of seed is an average yield.

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CHAPTER XV

FOOD PLANTS

CASSAVA. *Manihot utilissima.*

Habitat. History of the plant.

THE cassava plant is a native of South America, where it is found from Guiana and Colombia to Brazil and Peru. Its cultivation by the inhabitants of tropical America dates far back, and it has always formed a great portion of their food. From the grated tuberous roots they obtained not only meal and bread, but they also manufactured by fermentation an intoxicating drink called *piwarri* from cassava cakes, which were first chewed and then spat into the wooden fermenting vessels. The plant is now cultivated extensively throughout most tropical countries. The flour obtained from the large tuberous roots has the appearance of coarse oatmeal and is everywhere an important food containing much starch and other nourishing matters.

Cultivation in the West Indies.

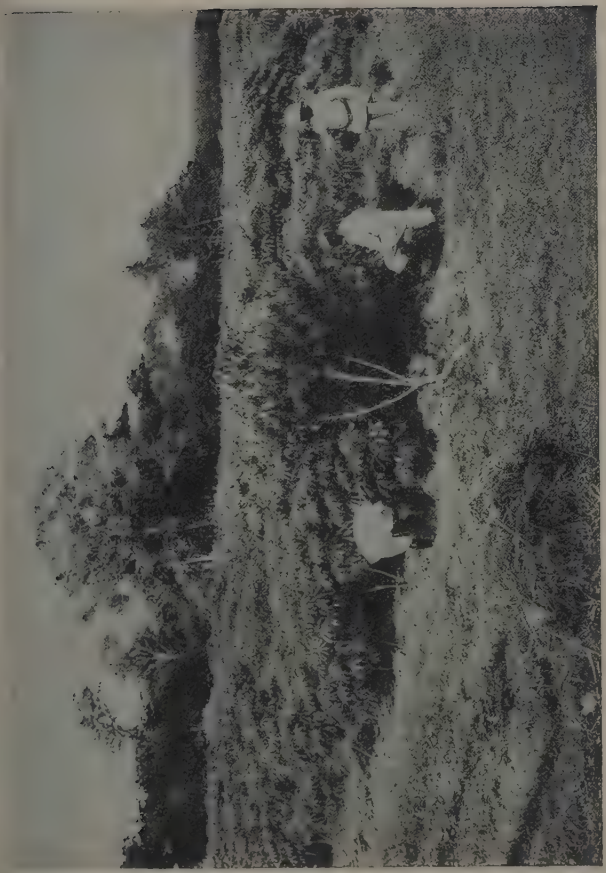
Tapioca.

Tapioca, one of its products, is well known as a light, easily digestible article of food for children and invalids.

Productiveness of the plant.

The cultivation is simple and inexpensive, and the returns are large; indeed, the plant is said to be one of the most productive in the world, an acre of cassava yielding more nutritive matters than six times the same area under wheat.

Cassava is a shrubby plant with knotty stems growing to a height of from five to eight feet, and the roots swell out into large tubers of a yellowish colour. These tubers sometimes attain to a very large size, often reaching 24 to 36 inches in



CASSAVA FIELD, JAMAICA.
[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

CASSAVA: PLANT-ROOT EXPOSED, JAMAICA.

[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

length, according to variety. There are two species, one, bitter cassava (*Manihot utilissima*) and the other sweet cassava (*Manihot palmata*, var. *Aipi*). Sweet cassava may be used as a vegetable without any preparation; but bitter cassava contains juice of a very poisonous nature. This poisonous juice, in which there is much hydrocyanic or prussic acid, is fortunately dissipated by heat and so the bitter cassava is more commonly cultivated as it gives much larger returns. There are numerous varieties, often confined to certain countries—as, for instance, in the West Indies, Brazil, India, &c.—native or introduced.

The poisonous juice.

Varieties.

Soil and Climate.—The best soil is a sandy loam which must be well drained, for the roots soon decay in water-logged ground. The soil, too, must be rich, for cassava is a very exhausting crop, and without manure it cannot be raised on the same land more than two or three years running. The climate should be a hot and dry one, and the plant thrives best in the lowlands near the sea. No shade is necessary, and high winds do no harm.

The best soil.

Manuring.

Climate.

Cultivation.—The modes of propagation and cultivation are simple. Full grown woody stems are cut up into pieces from four to six inches long, and these are set in a slanting direction in the ground, with about an inch left above the surface. Previous to planting, however, the soil should be well prepared by ploughing and cross ploughing; or, on a small scale, it may be worked up with the hoe or spade. Another plan is to plant the cuttings in small shallow holes filled in with good surface soil, or in furrows made at the proper distances with the plough. The distances vary from four feet to six feet each way, the wider distances being chosen on the best land. The cuttings will begin to grow in about a fortnight after planting, and the ground must be kept free of weeds until the plants grow up and cover the land with thin vegetation, which they will usually do in about three months from the time of planting. In

Cuttings.

Distances.

Weeding.

weeding with the hoe or cultivator between the rows, care must be taken not to turn up the soil too deeply, for otherwise the lateral roots which bear the tubers will be injured and thus interfere with the yield.

The crop time.

CROPS.—Planting having been undertaken between September and May, the crops may be reaped in from eight to twelve months afterwards, but the roots can be left in the ground for a considerable time without injury. In harvesting, the tubers are carefully lifted and separated from the fibrous roots, and washed so as to remove all adhering earthy particles. They must then be manufactured into the commercial product without delay, for they soon dry or decay after they are dug up.

Washing the tubers.

Peeling the tubers.

Grating.

PREPARATION OF CASSAVA MEAL.—The tubers, after they have been washed, are divested of their dark-coloured rind by being peeled with sharp knives. The peeled roots are then reduced to a coarse meal by being pressed against a rapidly revolving wheel covered with a copper or tin grating surface, or they may be rubbed down to meal by means of a flat tin grater nailed on a board. In the latter case, however, the operation is very laborious; but, nevertheless, a large portion of the cassava meal made in Dominica and elsewhere is prepared in this tedious way: the natives fix the large flat grater against a tub, and, leaning over it with tubers in each hand, they grate quickly and rhythmically to the sound of a drum and they are encouraged to extra exertions by the stimulating influence of inspiriting local songs, and more often than not by large potations of intoxicating drinks. The pulp is then put into bags and pressed so as to force out the poisonous juice. The Indians of Dominica and South America press the pulp by means of curious baskets called *matapies*. These baskets are made of plaited strips of the long smooth stems of a native plant closely allied to that producing arrowroot. When empty the matapie is long and narrow, but when

Grating manioc in Dominica.

Pressing out the poisonous juice.

The matapie.

TAPIOCA FACTORY: ROOTS IN PREPARATION, SINGAPORE.
[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

TAPIOCA FACTORY: PREPARING THE STARCH, SINGAPORE.

filled with the grated roots it becomes short and thick. It is then hung up to the branch of a tree and heavy weights are attached to the lower end. The basket then becomes longer, and by the constricting pressure most of the juice is forced out. Afterwards the meal is sifted by means of sieves, which separate the woody fibres and the small portions of the roots that have not been properly grated. The meal is then dried rapidly in large, shallow, flat iron pans set in masonwork, with a flue passing underneath so as to conduct the heat from a wood-fire. The meal is spread thinly in the pan and constantly moved backwards and forwards with a wooden rake. The heat must not be so great as to brown the meal, the object being not to bake the product but to dry it. In the process of drying, any remaining traces of the highly poisonous juice are rapidly dissipated. Cassava bread is simply the fresh wet meal formed into thin round cakes, and dried on hot plates, or on flat pieces of tin held over a fire.

Sifting the meal.

Drying the meal.

Cassava bread.

CASSAVA STARCH.—The starch made from cassava is of a very superior nature; and, as it can be made cheaply, and in great quantity, it has become an important article of export from the West Indies, Brazil, &c. The method of preparation is very simple. The grated cassava meal is stirred up with water and then passed through sieves. This is done several times so as to wash the starch clean, and the mesh of the sieves is decreased in size after each washing so as to leave the starch free from any foreign substance. After the last washing the water is allowed to remain for a time, when the starch will settle at the bottom of the vessel; the clean fluid on top is then drawn off or decanted, and the starch is dried in the sun.

Preparation of the starch.

Washing the starch.

Drying the starch.

TAPIOCA.—In the account of the preparation of cassava meal we have seen that the juice is forced out of the rasped roots by pressure. Now, if this poisonous juice be allowed to settle, a considerable quantity of very fine starch will be

The fine starch.

deposited. The juice is poured off, and the starch is heate on tin plates or in flat iron pans; the starch grains the swell up and burst, and become agglutinated together, thu forming the tapioca of commerce, exported from Brazil an Malaya. The main sources of cassava products—"Man diocca or tapioca flour," "cassava powder" and "tapioca —are Java, Brazil and Straits Settlements, the import into the United Kingdom being approximately 50,00 tons per annum.

The burst-ing of the grains.

CASSAREEP.—The poisonous juice of the tubers of the bitter variety of the cassava plant should not be thrown awa as it can be converted into a valuable product known widel as cassareep. The juice is simply boiled down until i becomes of the consistence and appearance of molasses. I this condition it is a powerful antiseptic, and it is capable o preserving all kinds of meat in a fresh condition for con siderable periods. It is the basis of many celebrated sauces and of the well-known *pepper-pot* of the West Indies. Thu by reason of the boiling process, this highly poisonous juic is converted into a wholesome food product, for which there is usually a ready sale in England and elsewhere. As the juice of the bitter cassava contains so much of the poisonou prussic acid, the greatest care must be taken to keep i away from children and animals. Many deaths have been brought about by carelessness in the disposal of the juice so that too many precautions cannot be taken to preven accidents. It may be mentioned that the Indians of Guian use red peppers (Chillies) steeped in rum as an antidote t the poison.

The poison-ous juice boiled down.

Antiseptic qualities of cassareep.

Dangerous nature of the poison.

Antidote.

ARROWROOT. *Maranta arundinacea.*

ARROWROOT is a white, tasteless and odourless powder substance—consisting of starch granules, and used as bland article of food, more especially for children an invalids. It is obtained from the white, fleshy rhizomes— sometimes called tubers—of a reed-like herbaceous plan

Habitat.

found growing wild in tropical America and the West Indies. The name arrowroot is derived from the fact that the rhizomes were used by the Indians as an application to wounds inflicted by poisoned arrows; and, even now in Dominica the starch and the pounded tubers are used by the people to make poultices for healing wounds and ulcers.

Origin of the name.

The plant is cultivated in Bermuda and St. Vincent, as well as in the East Indies and Natal. Bermuda arrowroot was at one time produced in great quantity and realised the best price in the home markets. The superior quality—which it still retains—is attributed to the extreme care and cleanliness exercised in the different processes of manufacture; probably also to soil, culture and to a good supply of clear spring water available for treatment. At the present time the island of St. Vincent is the chief source, and the product—averaging about 5,000,000 lbs. a year—ranks high for quality. The industry is under the protection of an Association of Growers and Exporters.

Bermuda arrowroot the best kind.

Reason for its superior quality.

St. Vincent arrowroot.

Soil and Climate.—A light loamy well drained soil is the best for the cultivation. If the soil be too wet the rhizomes will rot off; and, if it be of a clayey nature, they will not develop properly, and there will be much difficulty in digging them up when they are mature. The plant will grow very well on lands near to the sea; and, as it does not attain to a greater height than three feet, strong winds do not affect it injuriously. The richer the land, the greater will be the returns; and, if successive crops be taken off the same soil, manuring will become necessary. As much water is required in the manufacture of the starch, the cultivation should be established only in the neighbourhood of a stream or a spring of good clear water. Arrowroot will grow from the coast line up to elevations of several thousand feet above the sea, but the returns are larger in the lowlands, and largest in the rich valleys situated at elevations of two or three hundred feet. The crops are "less affected by vicissi-

The best soil.

Climate.

A good supply of water essential.

Elevation.

ARROWROOT PLANT (*Maranta arundinacea*), SHOWING THE RHIZOMES.

[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

tudes of weather than almost any others that can be produced" in the tropics, wet weather and dry weather appearing not to alter the yield to any appreciable extent provided the soil is good.

CULTIVATION.—The plant is propagated by means of young shoots detached from the parent stool, or by division of the rhizomes. The land should be ploughed deeply and then harrowed. Afterwards furrows are made to a depth of six inches at the distance of three feet from each other. The shoots are planted in these furrows about twelve inches apart, and covered with soil either by means of the plough or the hoe. The land is kept weeded; and, in the early stage of growth of the plants the soil may be advantageously turned over between the rows by light ploughing. It has been advised that the flowers should be cut off as they appear, so that the rhizomes may be increased in size and number by preventing the waste of the strength of the plants in the effort of flowering. Such a system is in accordance with scientific teaching, and its adoption is to be recommended.

Propagation.

Furrows.

Weeding.

Cutting off the flowers.

CROP.—Returns may be expected in eleven months, and as May is the best month for planting, the rhizomes may be dug up in March or April, and they will then be found to be densely packed with starch granules. The maturity of the rhizomes is known by the flagging and falling down of the leaves; and when this occurs the plants should be dug up with the fork, and the rhizomes should be broken off from the leafy stems, and washed so as to remove the adhering particles of earth. In the process of lifting the plants, small pieces of the stems and roots are always left in the ground, and from these remnants fresh plants spring up. For this reason, it is very difficult to eradicate arrowroot from land where it has once been cultivated, for the plant is of a hardy nature, and thus very small portions of the rhizomes are capable of growing into large clumps. The rhizomes contain twenty per cent. or even more of

Returns in eleven months.

Digging up the rhizomes.

The hardy nature of the plant.

the starch, but owing to the rude processes of manufacture usually employed to separate the fecula, it is seldom that more than fifteen per cent. is obtained, and this would give about seven hundredweights of prepared arrowroot to the acre. But with high cultivation on rich soil much larger returns may be looked for; yields may vary from 5 to 20 barrels (220 lbs. each), but a fair average is given as 8 barrels or approximately fifteen hundredweights per acre.[1]

Returns per acre.

Paring the rhizomes.

PREPARATION OF THE ARROWROOT. — The rhizomes having been dug up and washed they are to be pared with sharp knives so that every portion of the outside skin is removed; and, at the same time, all unsound portions are cut away. The skin contains a resinous substance which would discolour the arrowroot and give it a disagreeable flavour; it is necessary, therefore, that great attention be given to the paring of the rhizomes. After the skin is removed, a second washing is necessary; and then, in order to get out the starch, the rhizomes are to be reduced to a pulp. This may be effected in three ways; namely, 1. By pounding them in wooden mortars; 2. By passing them between the rollers of a mill; 3. By pressing them against a rapidly revolving wheel covered with rough tin like a nutmeg grater—which tears the mass to pieces. In places where arrowroot is cultivated on a moderately large scale the last mentioned pulping process is the best, for the grating mill can be made at very little expense. The next thing to do is to mix the pulp thoroughly with good clear water, and then to pass the whole through a fine sieve which separates the fibrous substance and permits the fecula to be carried off with the water through the meshes of the sieve. The fibrous refuse is thoroughly squeezed to force out any of the starch entangled in it, and it is then thrown away, or, preferably, used as manure for the next crop. The water and the starch are run into cisterns or tubs and allowed to settle, when, after a time, all the starch will subside to the bottom

The resin in the skin.

Washing.

The three methods of preparing.

The grating mill.

The fecula separated by sieves.

The settling of the starch.

[1] In St. Vincent—W. India Comm. Circ., July 12th, 1928.

and the water can be drawn off. The fecula is then stirred up with fresh water, passed through a second sieve of a finer mesh—which may be of brass wire or muslin, and allowed to settle as before, the supernatant fluid being drawn off when all the starch has fallen to the bottom. This process may be repeated several times, or until the water appears perfectly clear over the starch. The object of the several washings is to remove everything from the pulp but the starch, which, in its pure state, is the arrowroot of commerce. After the last washing the water is drawn off, and the pasty starch is taken out of the tubs or vats and put on trays with calico bottoms to drain and to dry, the drying process being usually effected in the sun or in sheds, the sides of which are left open or enclosed simply with galvanised wire netting to allow a free circulation of air. In Bermuda it is calculated, according to Simmonds, that "four barrels of peeled and cleaned rhizomes will yield in "good seasons about 100 lbs. of good arrowroot, and will "take from five to six puncheons of clear soft or tank water, "it will be about twenty-fours hours in the water from the "time of grinding till it is upon the cloths or drainers." The arrowroot will take about three or four days to dry properly; but the hotter the sun or the drier the air and the more quickly the product is desiccated, the whiter will be its colour and the better its quality. After it is dried the starch will be in cakes which will have to be broken up into small lumps before it is packed. Arrowroot, when made properly, will keep a very long time without spoiling if it be packed so as to exclude the air, for it absorbs moisture readily, and it acquires the odour of any decomposing or strong smelling substances brought close to it. Unless, therefore, it is sealed up in tins, it should not be shipped in vessels carrying sugar, hides, &c. In St. Vincent, the arrowroot is shipped in tins containing 25 lbs. or 50 lbs., and in well-coopered American flour barrels, which are lined with paper gummed together with arrowroot paste.

Washing the starch.

Draining and drying.

The advantages of quick drying.

The air to be excluded from the arrowroot.

Cleanliness essential.

In the process of manufacture the greatest cleanlines must be observed, and care must also be taken to exclud dust and insects from the arrowroot. On estates in S Vincent and Bermuda, where the starch is made in larg quantities, the buildings and the machinery are kept scru pulously clean, and highly polished German silver shovel Glass houses. are used to take up and pack the arrowroot. In St. Vincen too, the various process of manufacture and drying an packing are done in houses roofed with glass so as to kee away dust and other foreign matters, and thus to ensure th making of a product of great purity.

TOUS-LES-MOIS. *Canna edulis.*

Cultivation in St. Kitts and Queensland.

A KIND of arrowroot called tous-le-mois was imported into England from St. Kitts about the year 1836; and was found to be a valuable article of food. The same plant is cultivated in Queensland, where it is known as "purple arrowroot," to distinguish it from *Maranta arundinacea*, which the growers call "white arrowroot."

The starch granules are very large.

The starch granules of tous-le-mois are very large, and can be distinguished with the unaided eye; whilst, in the case of all other starches, with the exception of that from the potato, the granules can only be detected by means of the microscope.

Habitat.

Tous-les-mois is obtained from the fleshy underground stems, or tubers, of *Canna edulis*, a plant closely allied to the *Marantas*, and found growing wild in Brazil, Peru, and Trinidad. Other varieties of *Canna*, producing tous-les-mois, are natives of Jamaica, Dominica and St. Kitts, but *C. edulis* is the one usually cultivated for the sake of its starch. It is a very hardy plant, and in Peru, where it is Description of the plant. called *Adeira*, it is eaten like potatoes. The flowers are highly coloured; in *Canna edulis* they are bright red, and in other species they are various shades of yellow and orange.

The plant is a very ornamental one, and, for that reason, is cultivated in English hot-houses. The seeds are round, hard and black, and it is said that they have been used by the natives of India as shot, and hence the name "Indian shot," applied to *Canna indica* and cannas generally. Tous-les-mois is very soluble in boiling water; and, on this account, and because of the large starch granules composing it, medical men recommend it as one of the best starchy foods for children and invalids. Useful qualities of the starch.

The plant is propagated by division of the underground stem, or by seeds which will germinate after being kept for many years. The land is ploughed up and prepared in the usual way, and the sets are planted a few inches under the ground in rows three feet distance each way. The cultivation of the plant is similar in every respect to that of ordinary arrowroot, and the starch is prepared in the same way as the arrowroot starch, which has been fully described in the preceding section of this chapter Propagation. Cultivation.

THE YAM. *Dioscorea alata*, and other species.

YAMS are the esculent tubers of several species of *Dioscorea* that have been cultivated in warm countries for ages. More nutritious than the common potato, they supply an abundance of wholesome food to the inhabitants of tropical and sub-tropical regions; and, in the West Indies, they enter very largely into the diet of all classes of the population. Most of the cultivated varieties of yams are probably natives of tropical Asia, that have been introduced into the West Indies at an early period of their colonisation by Europeans, and now become almost wild. The only yam of good flavour and food value, that naturally belongs to the flora of the West Indies, is the "waw-waw" of Dominica, *Rajania pleioneura*, which grows abundantly in the forests of that island. It is dug up by the woodmen and sold in the markets of the chief Food value of the yam. Habitat. The wild yam of Dominica.

YAM PLANT (*Dioscorea alata*), SHOWING TUBERS EXPOSED, JAMAICA.
[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

FIELD OF YAMS (*Dioscorea alata*), JAMAICA.

[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

town, for it is deservedly held in much estimation. After the hurricane of 1883, when most of the provision grounds in Dominica were laid waste, many of the country people subsisted for weeks almost entirely on waw-waws, dug up in the forests. All the yams are the produce of plants with slender twining stems measuring often as much as twenty feet in length, and bearing underground tubers which spring from the principal roots. The tubers vary in size and weight from the small cush-cush no larger than an ordinary potato, to the enormous yam weighing thirty or forty pounds, and measuring three feet in length.

Description of the plant.

Cultivated varieties not well defined.

The cultivated varieties of yam appear to be more or less uncertain as to their origin. The main difficulty seems to be that of securing adequate materials for the determination of varieties. The systematic study by Prain and Burkill, especially in reference to those of India, West Africa and West Indies, is well advanced, but the final report has yet to be made. The following are commonly cultivated in the tropics; others might be mentioned if space permitted.

WHITE YAM, WHITE MANILA YAM, or as more particularly specified GREATER YAM (*Dioscorea alata*, Linn.), also known as "Barbados yam," "ten months' yam," "wing-stalked yam," and under numerous varietal names in Jamaica and West Indies. There are numerous races cultivated more or less throughout tropical Africa, West Indies, India, Burma, Ceylon and Polynesia. It is the most common of all the cultivated yams in India and Indo-Malaya. The tubers are white in colour, and often very large, 22 to 55 lbs. in the Philippines; a particularly large one of 29 lbs., after being nine months in the ground, is recorded in Singapore.

Numerous races of yams exist.

Tubers often vary large.

NEGRO YAM, GUINEA YAM, WHITE YAM (*Dioscorea rotundata*, Poir.), also known as the "white" or "eight months' Guinea yam," of West Tropical Africa, and probably grown throughout tropical Africa and the West

Indies. Cultivated in former days as a food for slaves, and at the present day, in West Africa, in the Niger and Cross River Region, large areas are grown and stored for several months in the dry season until thoroughly dry and mature. In one village (Unan) the reviser noted bin-like structures, made of strong poles, 120 feet by 15 feet, carrying approximately 10,500 yams, and ten more structures of about the same dimensions in the course of preparation. Storing

GUINEA YAM, YELLOW or TWELVE MONTHS' GUINEA YAM (*Dioscorea cayenensis*, Lamk.), commonly cultivated in West Africa and West Indies. In Jamaica it is known as "afou" or "afoo" yam, "yellow yam" in Trinidad, "connie yam" in Tobago, and in Porto Rico as "Congo amarillo." Usually regarded as a yam of good quality, and very popular among the West Indians, though it is described as having coarse yellowish-white flesh with a flavour somewhat bitter unless fully ripe. The bitterness may also be due to exposure during growth, like the "greening" of potatoes : heavy damp soil is also said to be the cause of clammy and unpalatable tubers, which in good open, well-drained soil are usually dry and mealy when cooked. In Jamaica it is said to thrive in hot districts and is not so readily affected by unfavourable climatic conditions as the more delicate white yams. The tubers are large, several pounds (15–20) in weight, and they can be harvested in certain places, as in Jamaica and Trinidad, for instance, —while the plants are kept growing—practically all the year round. Tubers of "Guinea yam" of large size.

POTATO YAM, OTAHEITE POTATO (*Dioscorea bulbifera*, Linn.; var. *sativa*, Prain). Known throughout tropical Africa, where in the West it is known as "akam"; naturalised in the West Indies—known there as "acom" and commonly cultivated in the eastern tropics, the wild plant also being found in India, Burma and across the Pacific ; also known as the "Danda yam," "Carib potato,"

"climbing air potato," and "Turkey liver yam." The root-stock is variable and usually large under cultivation. It does not appear to be so valuable for food as the above mentioned, and the plant is remarkable in bearing good-sized tubers on the climbing stems which are edible. The tubers of "acom" in Jamaica are said (Harris, Bot. Dept., Jamaica) to be rarely eaten, but a good starch is obtained from them, whilst the underground tubers of the wild plant are stated (Watt, "Com. Prod. India") to be insipid and often hardly edible unless boiled repeatedly and washed in running water, though in times of scarcity and famine they are an important food in India.

CUSH-CUSH YAM of Trinidad or YAMPI of Jamaica (*Dioscorea trifida*, Linn.). There are several varieties of this yam, the tubers varying in colour of the flesh—white, pink or purple—and in size and form roughly about that of a large potato. The plant is prolific, sometimes bearing a dozen tubers, usually found to be of excellent quality.

The best soils.

SOIL AND CLIMATE.—All the yams require a rich sandy loam, deep and friable, for the rich tubers will not be able to develop properly in stiff, heavy soils. The white yam, however, will grow well on calcareous soils of a moderate depth. Good drainage is necessary, and this applies to most plants bearing underground tubers. The climate must be warm, but not necessarily hot, as the plant thrives in the mountains and in extra-tropical regions. A considerable rainfall and thorough tillage are essential conditions to successful cultivation.

Climate.

Propagation.

CULTIVATION.—Most of the yams are propagated in the following way: When the tubers are ready to be dug up, the tops are cut off with the vines attached and care is taken not to disturb the plant more than is really necessary. The top is then buried again in the ground, and it and the base of the vine is moulded up with good soil, and left

undisturbed for about three months, when another yam, called the *head*, is produced. Plants are then made by cutting the head into pieces, care being taken that each cutting possesses an eye, or bud, from which the new plant develops. Yam plants.

The land is usually lined out at distances of two feet each way, or in rows three feet apart, the plants being set at from three to six feet in the rows. At the site of the pickets the land is dug up, all stones and roots being removed, and the surrounding soil is then raked up so as to form small hills in which the yam plant is set several inches below the surface. In each hill, a stout stick eight feet long is simply fixed at the side of the plant so as to form a support for the vine to climb on. Sometimes two plants are set in each hill. The land must be kept weeded, and an occasional moulding up may be necessary, as the heavy rains tend to wash down the hills. Catch crops of maize, and sweet potatoes are sometimes taken off the land between the rows, but this system is a bad one except in very rich soil. From January to April is the best planting season, and the yams require from eight to twelve months to mature. Planting may, however, be undertaken at any time under suitable climatic conditions for a steady supply of the tubers. Distances. Hills. Supports. Moulding the plants. Yams may be planted according to season.

It has been calculated that an acre of land will yield four or five tons of yams in the year, and it is said that the same quantity of sweet potatoes may be taken as a catch crop off the ground, this brings the return up to nine tons—that is the yield of ordinary potatoes from an acre of good land in England. The yield, however, is variable, more than double the above returns or as much as 18 to 20 tons having been recorded. The fresh yam is not a suitable product for export ; any trade in the tubers, except perhaps for comparatively short distances by sea, is confined to inland routes, and no export trade in either dried roots or flour has been developed as with cassava. Returns.

The Sweet Potato. *Ipomœa Batatas.*

Habitat.

The origin of the plant producing the sweet potato is obscure, but it is thought by botanists to be a native of both hemispheres. It formerly grew wild in the woods of the Malayan Archipelago, and *batatas*, a Malayan word, is the name given to the potato in the far East. The tuberous roots of the plant are said to have been first mentioned by an author named Pigafetta, who visited Brazil in the year 1519, and found the potato in use among the Indians as an

History of the plant.

SWEET POTATO—LOBED AND ROUNDED ENTIRE LEAVES.
[*From "Southern Field Crops," by J. F. Duggar.*

article of food; it is probable, therefore, that it is a native of South America. Soon afterwards the plant was carried to Spain, and it spread over Europe, and was introduced into England long before the common potato. Dr. Pavy says, "The tubers were imported into England by way of Spain, and sold as a delicacy before the potato was known, and it forms the article referred to when the name is mentioned by English writers previous to the middle of the seventeenth century." Sweet potatoes are now cultivated for food in all the warmer regions of the globe, and in some countries they are recommended as a promising source of alcohol—yielding 35 gallons per ton.

Wide distribution of the plant.

Tubers a source of alcohol.

SWEET POTATO.
Slips 6 to 7 ins. high ready for planting in the field.

SWEET POTATOES ATTACHED TO PIECE OF PLANTED VINE.
[*From "Southern Field Crops," by J. F. Duggar.*

Description of the plant.

The sweet potato is a perennial with a trailing herbaceous stem and purple flower. The stems are from six to eight feet long, sending out roots at every node that rests on the ground. The original roots, and those sent out from the stems, bear many tubers—one plant yielding sometimes as

The tubers.

many as forty or fifty potatoes of various sizes. The tubers in rich soil, grow to a large size and commonly weigh from three to twelve pounds each when fully grown. A fair

Varieties.

average appears to be from one to three pounds. There are upwards of fifty varieties with lobed or rounded entire leaves, &c., selected as to whether the tubers are intended for table use (usually white potatoes as "Southern Queen," "White Sealy," &c.), or for feeding stock (usually heavy croppers as "Southern Queen," "Red Bermuda," &c.), or for export.

The best soils.

Soil and Climate.—The best soil is a light friable one with but little clay in its composition. It should be so well drained as to be rather dry, and to produce large crops it

Climate.

must be enriched with vegetable matter. The climate must be a warm one, and, although the plant will grow in the mountains, up to considerable elevations, it thrives best in the hot lowlands where the annual rainfall is at least from 30 to 50 inches.

Propagation by cuttings or rooted slips.

Cultivation.—Plants may be propagated by rooted slips (see p. 449), raised by planting tubers 2 to 3 inches apart in nursery beds or by cuttings of the stems. These are the best methods, but it is possible to use pieces of the tuber with eyes as sets. The cuttings should be about twelve inches long, and about half of their length is buried in the soil. They take root readily, even in dry weather, and grow

A good tilth necessary.

vigorously when rooted. After being well ploughed, the land is ridged with the plough or hoe, the ridges being at a

Distances.

distance of 2 to 4 feet from each other. The potato slips or cuttings are then set in the ridges a foot or two apart.

When the vines commence to grow the ground is weeded, great care being taken not to injure the foliage of the plants. At the second weeding it may be necessary to mould up the potatoes if heavy rains have washed down the ridges. Sweet potatoes should not be grown constantly in the same land, but should be rotated with other crops (see p. 71); maize (*Zea mays*) and other cereals, yams (*Dioscorea alata* and other species), beans (*Phaseolus lunatus*), cow peas (*Vigna Catiang*), pigeon peas (*Cajanus indicus*) or other leguminous crop may be adopted. This system is treated of in the first part of the book, under the heading of rotation of crops; but in cases where this method is not convenient, manuring becomes essential.

Weeding.

Rotation.

Manuring.

Crops.—Sweet potatoes are usually planted from September to May, and crops are gathered in from three to four months from the time of planting. Unripe potatoes change to a more or less green colour when cut through; but when ripe they do not change colour. The returns are usually considered to be from four to five tons to the acre, or more, according to the variety, under favourable conditions. After the first crop is dug up the stems and roots should be carefully covered with mould, and a second crop may be obtained in a month or two afterwards. Indeed, in rich soil, several successive crops may be gathered from the same plants. The leaves and succulent stems make excellent fodder for horses and cattle, besides which sheep, goats and other herbivorous animals are extremely fond of the potato vines.

Returns.

Successive crops.

Fodder.

Eddoes. *Colocasia Antiquorum* (*C. esculenta*). Tania. *Xanthosoma sagittifolium*.

Eddoes are the bulbous rootstocks of a plant commonly cultivated in most tropical countries. It is a native of India, but it has been grown in Egypt from time immemorial, its former botanical name, *Colocasia Antiquorum*, indi-

Ancient cultivation of the plant.

cating that it was cultivated from the earliest known times. Like other widely distributed food plants, there is a good deal of confusion in regard to the nomenclature. In Jamaica the plants are called cocoes, and in other parts of the West Indies they are called eddoes and tanias, the last mentioned

Nomenclature.

EDDOES. *Colocasia Antiquorum* (*C. esculenta*).

name being spelt sometimes tannias, taniers, and tanniers. In the Pacific islands they are known as taros, and an old French writer on Santo Domingo alludes to them as tayaux. The above name has been adopted by the author, for the reason that it is the one most generally used throughout the West Indies and South America, and because it is

Eddoes and tanias.

employed by the old writers on these islands. The Jamaican name, cocoes, should certainly be discarded, inasmuch as it is liable to be confused with cacao, coca, and coco-nut, owing to its similarity of spelling and of sound.

Description of the plant.

The plant, of the Aroid Family, is a very handsome herbaceous one. It has only a short stem, and the large arrow-shaped leaves are borne on long petioles or foot-stalks rising from the ground. The rootstocks ("corms") are often as much as six or seven inches in diameter, and they contain a large proportion of starch which renders them very nourishing food. They contain, also, an acrid substance which, however, is dissipated by the heat of cooking. When boiled, the eddoes—which are white internally—turn to a yellowish colour. They are used as vegetables like potatoes, and they make a most nutritious soup. An excellent starchy food, resembling arrowroot, may also be obtained by grating the roots and washing out the starch in the manner described in the section of this chapter relating to arrowroot. There are two principal varieties or forms, one with green stems and leaves, and the other with purplish ones; but the rootstocks are alike in both kinds. The young leaves are sometimes boiled and eaten as spinach, and the mature leaves and stalks are excellent fodder for cattle, and food for pigs.

Food value of the plant.

Varieties.

The value of the leaves.

The best soil.

Soil and Climate. The best soil is a sandy loam with an abundance of organic matter in it. The plant does not do so well on clayey soils, and it does not thrive on pure sands. All warm climates are suitable for the growth of *Colocasias*, and they bear great extremes of heat and moisture within the tropics. They give the best returns when there is abundance of moisture, but they also bear well in dry situations.

Climate.

Propagation.

Cultivation.—The plants are propagated in the same way as are yams. That is, when the crops are reaped, the head of the bulb-like root is cut off and the leaves are

detached, leaving a few inches of the lower part of the leaf-stalks. These heads are then planted, and soon a number of plants bud forth from the top of the head, thus producing a fresh crop. The heads may be kept some time before planting without suffering any harm, and may therefore be carried to long distances. The land should be well ploughed up and harrowed, and the heads set in the ground at distances of from three to four feet from each other. Or the land may be lined off and small holes prepared, in the usual way, for the reception of the plants. Weeds must be kept down by hoeing between the rows, and the soil should be stirred up at the same time. Plants are often put out as shade for young cacao plants, their large, cool, succulent leaves—which give off an abundance of watery vapour—affording an excellent shade for, and providing grateful moisture to the cacao seedlings.

Distances.

Eddoes and tanias as shade plants.

The planting season.

CROPS.—Fields may be planted all the year round, except in very dry weather, but the usual planting season depends upon local conditions, and the crops may be reaped within from nine to twelve months. One advantage found in cultivation is that the roots may be allowed to remain in the ground, without deterioration, for a considerable time after they are ripe, so that they can be dug up as they are required.

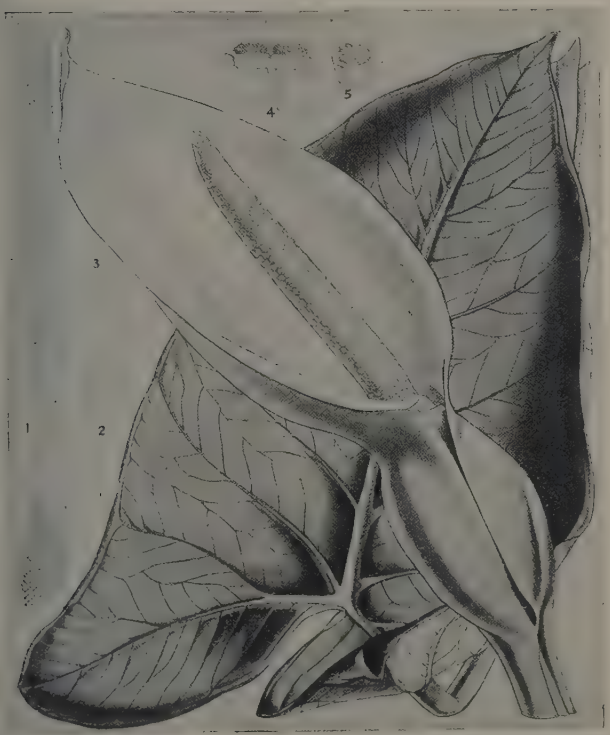
Returns.

In good land the returns are large, one head often affording enough plants to yield nearly a bushel of produce.[1]

The blanched shoots of the plant as a vegetable.

When grown for blanched shoots, good-sized corms may be planted in moist sand or sandy soil with the bud just exposed, in a situation where it is possible to keep them in total darkness during the whole period of growth. The first crop of shoots—6 to 12 inches long—should be ready for cutting in about a month and ten days after starting. The may be cut close to the base, before the leaves begin to open and upwards of ten cuttings may be made at intervals of from ten to fourteen days, or until the plants are exhausted when a new lot of corms may be put in.

[1] From one hill grown from a single rootstock of "Trinidad Dasheen," Young (U.S. Dept. Agric. Bur. Pl. Industry Circ., Dec. 5th, 1914) gives 4 to 10 lbs. or more.



TANIA (*Xanthosoma sagittifolium*), LEAF AND FLOWER (REDUCED).

1, Spadix. 2, Stamen. 3, Abortive stamen (from the middle of the spadix). 4, Two ovaries, showing how they are united at the collum or neck. 5, Transverse section of an ovary (magnified).

[*From "Botanical Magazine," tab.* 4989.

The above notes by the author are left practically as they were—under the name "tania"—though they refer more correctly to "eddoes," a name which has since been found to be applied to *Colocasia Antiquorum* (syn. *C. esculenta*); "tania" or "tannier" being the popular name in the West Indies of *Xanthosoma sagittifolium*. Some confusion has existed more or less widely in the two plants and the literature has become considerably involved. The *Colocasia* has a peltate leaf (as illustrated) and the *Xanthosoma* a sagittate leaf, but for all practical purposes the two plants may be regarded as the same, being cultivated in the same way and for the same purposes in tropical America, West Indies, &c. "Taro," as mentioned above, is correctly the name of the *Colocasia* in the Pacific Isles or Polynesia. Other names are "coco" or "koko" in West Africa, "dasheen" in the West Indies, "yautia malanga" in Porto Rico, "gabis" in the Philippines, "kamu" or "gwaza" in Hausaland (W. Africa), and generally as "coco yam," "scratch coco," "Egyptian arum," "China potato" and "Carib cabbage." In Porto Rico "yautia" is another name for the *Xanthosoma*.

PULSES. Various species in the Family *Leguminosæ*

THE pulses are an important source of food in every tropical country, the following being those chiefly grown.

CHICK-PEA or BENGAL GRAM (*Cicer arietinum*), an annual plant, 1 to 2 feet high, cultivated in India, Africa, Mexico, &c., and one of the most nutritious of the pulses; grown everywhere for food in both tropical and sub-tropical countries. The parched seeds are also used in confectionery and the green pods as a vegetable. It is propagated by seed, sown broadcast or in drills; requires moderate rainfall, ample sunshine and a loamy soil. The plant is not suitable for fodder on account of the acid secretion of the leaves - but is a good cover and green manure plant, and is grown in

the cool season. It comes to maturity in about four months. An average yield is about 600 lbs. of peas per acre.

JACK BEAN (*Canavalia ensiformis*); SWORD BEAN (*Canavalia gladiata*). The former is a native of the West Indies and is cultivated in many parts of the Old World tropics for the seeds, the best for food being those that are white. The latter plant is widely cultivated in India, Philippines, tropical Africa, &c. The cultivation of both plants is comparatively easy, being grown from seed, which may be sown in rows about 2 to 3 feet apart and about 1 foot apart in the rows.

LIMA, BURMA, RANGOON or JAVA BEAN (*Phaseolus lunatus*); also known in the large white-seeded form as "Madagascar butter bean"; a tall biennial with the habit of the "runner bean," climbing upwards of 8 feet according to the variety. Under cultivation there are many varieties, which vary especially in the colour, size and shape of the seeds—white, black, brown, reddish and mottled. The Madagascar butter bean is the one commonly sold by grocers, and also the small white seeds have been sold as "haricot" or "new haricot" bean. It is only the white beans that are considered safe for food. The seeds have been found to contain prussic acid; usually the greater proportion is found in those that are coloured, but only a very small proportion in the white seeds.

The URD of India, WOOLY PYROL of Barbados (*Phaseolus Mungo*). The green pods and ripe seeds are used as food, and in India it is one of the most important crops. Cultivation is easy where the soil is well drained and temperature and rainfall sufficient. The plants come to maturity in little more than two months, an average yield being upwards of 500 lbs. of seed per acre. *Phaseolus radiatus* is the "mung" or "green gram" of India; it grows about 2 feet high, the seeds being small like those of *Mungo* and may be either green, yellow or black. A deep,

rich soil, good rainfall, upwards of 40 inches, and good tillage are recommended. About 12–20 lbs. of seed will sow an acre. It is an excellent quick-growing green manure.

The HARICOT or DWARF BEAN (*Phaseolus vulgaris*). There are many varieties under cultivation, the conditions being much the same as in gardens in England. Sow in rows about 2 to 3 feet apart and about 8 or 9 inches apart in rows, and about one inch deep, in a light, rich soil in an open situation; but in the tropics some protection (light shade) from excessive sunlight may be desirable. The seeds germinate in a few days, and the plants begin to bear in the course of a month or six weeks.

The COW PEA (*Vigna Catiang*) and PIGEON PEA (*Cajanus indicus*) are also commonly grown for food. See under Fodder Plants.

The LABLAB BEAN or INDIAN BUTTER BEAN (*Dolichos Lablab*), also known as "bonavist" in the West Indies, an annual climber, 10 to 15 feet; cultivated throughout tropical Asia, Africa and America for food. Grown on good soil with careful cultivation, sown at the rate of 5 to 8 lbs. of seed per acre, the yield of pulse per acre may range between 250 and 1,000 lbs. Some support is necessary when grown as a field crop, and "castor oil" (*Ricinus communis*) has been recommended as a suitable plant for this purpose. This bean is often grown as a garden plant as well as a field crop. The "horse gram" (*D. biflorus*) is also commonly grown for food in the tropics on poor dry soils. Bush varieties are grown in India as a field crop.

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CHAPTER XVI

FODDER PLANTS

THE developments in Tropical Agriculture have in many instances included the breeding of stock, with a consequent demand for fodder plants. Herbivorous animals running wild find it comparatively easy to live on the tropical vegetation they find in rank exuberance, but a living is not always to be had within the area such as stock on a farm would be limited to. Some selection and agricultural skill are therefore necessary to maintain supplies under cultivation, and it is often found more convenient and practicable to use introduced species—especially where the seed has to be bought from a nurseryman—than to develop or attempt collection of seed of native or wild plants. The following list includes (1) plants suitable for forage or soilage—that is, cut and fed to stock in the stall; (2) silage—cut and fermented in silos for use in the same way as hay; (3) hay crops and (4) pasture. Nothing, except perhaps at high altitudes, where the climate is temperate and ceases to belong to this work, can be attained in tropical countries that would approach the green pasture fields of temperate climates. The best fodder plants are almost entirely confined to the grasses and leguminous plants; the better known include:—

MAIZE OR INDIAN CORN. *Zea Mays.*

An annual plant 4 to 10 feet high, including many varieties; cultivated throughout the tropics and sub-tropics. Maize is commonly used for feeding to stock, parrots, poultry and game. The cake made from the germs after expression of

COW PEAS (see p. 479) GROWING BETWEEN ROWS OF MAIZE.
[*From "Southern Field Crops," by J. F. Duggar.*

the oil is recommended as a good feed for animals, especiall dairy cows, and in the manufacture of glucose from the seed. Maize germs. the residue is of value for feeding stock—known as "glute feed." For forage it is cut and fed green and is an excellen For cultivation refer to Food Plants. crop to grow for silage or hay. The yield for silage may average upwards of 20 tons per acre. See under Food Plants for general information as to cultivation.

Bermuda Grass. *Cynodon Dactylon.*

A perennial plant from a few inches to 2 feet or so in height; widely distributed in the tropics and many sub-tropical countries. It is an important fodder plant both for pasture and for hay in the West Indies, United States, The best-known grass in the tropics. Australia, India, and perhaps the commonest grass grown for pasture nearly all over the tropics. It may be readily propagated by seeds or by division of the rhizomes; sown broadcast, about 5 lbs. of seed per acre would be required; pieces of the stem planted about 8 inches apart might cover the ground in about six weeks' time. Open, moderately rich soil and a good rainfall are essential; but the plant Yield. stands drought well. From 2 to 5 tons of hay per acre is a good yield, and when pastured one acre per head of cattle should be allowed for.

Guinea Grass. *Panicum maximum.*

A perennial 3 to 6 feet high, sometimes over 10 feet indigenous to tropical Africa and cultivated in many tropical countries, including India, Brazil, Cuba, West Indies, East Indies, Gulf Coast States, Philippine Islands, &c. One of the best fodder grasses in the tropics, suitable for all kinds of stock, recommended as a soiling crop (cut green and fed to cows or horses in the stall), and, cut before the stems get Propagation. hard and woody, may be used as hay and silage. It may be propagated by seed, but is more commonly multiplied by division of the roots, planted on well-ploughed soil 2 feet or more apart. Given a fairly rich and well-drained soil and good rainfall, it grows quickly and comes to maturity in about

to 100 days. The yield per acre may vary from a few tons the first year to more than 100 tons when established, about the fifth or sixth year, and a large and continuous supply of forage may be kept up by several cuttings more or less the whole year round, for a good number of years. The moisture content is very heavy, and when cut for hay the loss in weight on drying is 60 per cent. at least. Yield.

PASPALUM OR GOLDEN CROWN GRASS. *Paspalum dilatatum.*

A perennial 2 to 4 feet and upwards; indigenous to Brazil; distributed by cultivation to the Gulf States, introduced to Australia, India, East Africa, Kenya Colony, Porto Rico, Mauritius, Straits Settlements, West Indies, &c.; strongly recommended as excellent for hay and pasture. May be propagated by seed—5 to 10 lbs. per acre—or by division of the roots—planted 4 to 5 feet apart for making permanent pasture, recommended to be mixed with some leguminous plant or other suitable grass. A rich soil with a good rainfall is desirable, but the plant is said to stand drought fairly well. Three cuttings, it is reported, may be made per annum, giving a total of about 30 tons per acre. It is recommended to be cut before the flowering stage. When cut and dried for hay about 2 to 3 tons per acre may be regarded as a good crop. This grass has been recommended for growing amongst rubber trees as a cover crop, and for feeding cattle. Propagation. Yield. A good cover crop.

CRAB GRASS, GREEN GRASS, SOUR GRASS. *Paspalum conjugatum.*

A perennial 1 to 2 feet high; common in tropical America, West Indies, tropical Africa, Malaya, Polynesia, Hawaian Islands, &c. May be propagated by seed, or an area may be readily planted up with young plants put in several inches apart, the ground soon covering by the

natural spread of runners. Recommended as a pasture plant.

NAPIER'S FODDER, ELEPHANT GRASS. *Pennisetum purpureum.*

A perennial, with creeping rhizomes, culms 6 to 10 feet and upwards. Native of tropical Africa. May be propagated by seed, but usually more convenient and effective to propagate by division of the roots. Recommended for cultivation as a soilage crop for both cattle and horses in Rhodesia, Cameroons, Uganda and other parts of Africa. The plant grows quickly, stands cutting well, and it is perhaps more valuable as a soilage crop (cut green and fed to stock in the stall) than for pasture or for hay—the culms being too strong and woody when mature for the latter purpose. Resists drought well, though it thrives best in moist or marshy land.

KIKUYU GRASS. *Pennisetum clandestinum.*

A perennial, comparatively low growing under dry conditions, 2½ to 3 feet high in moist soil with a moderate rainfall. Native of British East Africa (Kenya); cultivated in S. Africa. Propagated by division of the rhizomes, which run freely and soon cover the ground, with pieces planted about 6 feet apart. Seeds do not appear to be produced freely enough to allow of reliance on this method of reproduction on a field scale. Recommended for pasture, and may also be cut two or three times in a season for green fodder at comparatively high altitudes, and thrives in sandy soil, clay-loam, alluvium, &c., with a rainfall of about 30 inches.

Propagation by rhizomes.

Seeds scarce.

HONEY OR MOLASSES GRASS, STINK GRASS. *Melinis minutiflora.*

A perennial 3 to 4 feet, native of Brazil, occuring in tropical Africa, Madagascar, Ascension Island; introduced into Queensland, West Indies, S. United States, &c. An

excellent fodder plant for horses and cattle; may be used cut green, or as hay, and recommended to be cut before the seed appears. This grass, under the name of "Efwatakala" (Angola), has recently come into prominence as a possible preventive of the "tsetse" fly if planted on a large scale in the regions where this fly—so dangerous to horses and cattle—abounds. The yield may be from 3½ tons and upwards of hay per acre.

Suggested for protection against "tsetse" fly.

Teff. *Eragrostis abyssinica.*

An annual 2–4 feet high; native of Abyssinia; introduced to many warm countries, including Australia, India, British Guiana, East Africa, California and the Transvaal. Is valuable as hay and pasture grass, suitable for all kinds of stock. There are two main varieties recognised in Abyssinia, "Thaf Tseddia" (white) and "Thaf Hagaiz" (red); the former described as quick growing, coming to maturity in from two to three months, and the latter as slow growing, maturing in about five months. The seed weighs about 63 lbs. to the bushel and may be sown broadcast. The yield of green forage per acre may be from 4 to 7 tons, or of hay about 2 to 4 tons. The grass stands drought well, thriving in countries with a very low rainfall, and for this reason it has been proved of great value to dairy farmers in S. Africa and Australia.

Teff stands drought well.

Natal Grass, Red Top. *Tricholæna rosea.*

A perennial, but may be grown as an annual; native of tropical (more particularly in the eastern side) and South Africa; cultivated in the United States—Florida, &c., N.S. Wales, Transvaal, Rhodesia, &c., where it is recommended as a valuable hay-grass. In Florida, where it is recommended for growing between the trees in citrus groves, it is found to be the best grass for well-drained sandy soils, and in general the plant is said to resist drought well. May be propagated by seed or division of the roots; when seed is

Suitable for growing in citrus groves.

Propagation

used, sown broadcast about 2 to 3 lbs. per acre is required, and because of the downiness of the seed it is advisable to first moisten and roll in soil or wood ashes, to admit of even distribution. The plant comes to maturity in about three months, and the yield of hay may be from 2½ to 4 tons per acre. The bright red crimson seed-heads make this a good decorative plant, and for this purpose it is often grown in European gardens. In tropical countries it would perhaps be better grown at the higher altitudes.

Para Grass, Mauritius Grass. *Brachiaria mutica* (*Panicum muticum*).

A perennial, 3 to 6 feet high and upwards; native of South America and West Africa; introduced to the West Indies, Ceylon, India, Australia, &c. An excellent fodder grass: grows so freely in hot climates with a good rainfall that at times, if not actually a pest, growers seem liable to get too much of a good thing. Propagates readily from seed or by division of the root-stock or stolons. In Ceylon, where it is said to be the chief fodder grass for milk cattle, it remains green all the year round, and in Brazil, where it is cultivated for pasturage, it is considered unequalled for the quantity of feed it produces, and wherever it is grown large and continuous supplies appear to be available.

Propagation.

Chief grass for milk cows in Ceylon.

Carpet Grass. *Axonopus compressus.*

A perennial, 6 inches to 2 feet high; indigenous to tropical America and Africa; cultivated for pasture in the West Indies, S. United States, N.S. Wales, &c. Rich soil and a good rainfall are essential, though it may grow in comparatively poor soils. Hitchcock, an American writer on grasses, states that it is the predominant pasture grass in the United States from Virginia to Florida and Texas, in the lowlands along the coast in alluvial ground; of little importance in sandy soil and does not thrive on the uplands. In cotton soils or in alluvium it is said to thrive better than

A pasture grass in moist lowlands.

Bermuda grass, with which—for pasture—it may perhaps be compared as one of the best in the tropics; it is propagated in the same way, requiring perhaps a little more seed (upwards of 10 lbs.) per acre. The grass stands being close grazed, for which purpose it will carry approximately the same number of cattle per acre as "Bermuda."

SWEET SORGHUM. *Sorghum saccharatum.*

An annual, 10 feet or so in height; cultivated in China, India, United States, Egypt, &c., for fodder. A forage crop of importance in the United States, where it is also grown for the extraction of syrup. Sugar was at one time an important commercial product of this species, but apart from the use for forage, the varieties "Early Amber," "Orange," "Honey," "Sumac," "Gooseneck," and "Planter" seem to be only grown now for the production of syrup. Grows in soil containing salt. Thirty pounds of seed or more may be required to sow an acre; sown broadcast in ground prepared as for grain sorghum. A first cutting may be made about ten weeks after sowing, yielding 7 to 9 tons, and a second cutting a month or so later, and in general it is recommended to be cut before the seeds are ripe, and, moreover, it is perhaps best cut green and fed in the same way as maize. Some uncertainty attaches to sorghum as a fodder, and cases of poisoning have been recorded when pastured in a young stage. There seems to be considerable difference of opinion as to the exact stage at which the plant is free from danger to stock; but it seems to be generally agreed that it is not safe until it is at, or near, the flowering period, and that the poisonous effect of young green sorghum is due to the formation of prussic acid, though various hypotheses have been put forward as to the cause, based on climatic conditions, variety, nitrogen content of the soil, insect attack, &c. It is not possible to deal fully with the subject here; the above few lines are merely given

Sorghum poisoning.

as a note of warning. Numerous papers have been written on it (see footnote) which might be consulted.[1]

Two other sorghums might be mentioned—"Sudan Grass" (*Sorghum sudanense*), an annual, with slender stems 6 to 10 feet high, native of the Sudan, Upper Egypt. Seed may be sown broadcast about 4 to 8 lbs. per acre: yield after about three months from 3 to 5 tons of hay per acre suitable for comparatively dry regions. "Johnson Grass" (*Sorghum halepense*), a perennial 3 to 15 feet high, with creeping stoloniferous roots by which it may be propagated. Native of Western Asia, found in India, Burma, Ceylon, extending to the Mediterranean regions; naturalised in the hotter parts of the United States. A good fodder grass, especially for hay, but the plant spreads so freely when once established that it is liable to become a pest and difficult to eradicate when spread to places where it is not wanted.

"Johnson Grass" sometimes a pest.

Grasses of secondary importance.

The following grasses are good for fodder, but their use as such appears to be more limited to certain localities than the foregoing, over which not one of them would be likely to find preference.

Hæmarthria compressa, a perennial with erect stems 1 to 5 feet high, native of India and Australia, reported to be the principal fodder in Dacca, India; recommended for moist pastures and highly esteemed by graziers in Gippsland, Victoria.

"Swamp Couch."

Hæmarthria fasciculata, "Swamp Couch" (of Kenya and Uganda), native of tropical Africa; a perennial with erect stems 1 to 5 feet high. May be propagated by division o

[1] "Cyanogenesis in Plants," Part II, Dunstan and Henry in Trans. Roy. Soc., CXC, 1902, p. 399, and Proc. Roy. Soc. LXX, 1902, pp. 153-4; "The Poisonous Properties of Immature Sorghum," in Bull. Imp. Inst., 1910, pp. 384 8; "Cattle Poisoning by Juar (*Andropogon Sorghum*), with its Prevention," Taylor and Ghosh, in Agric. Journal, India, Oct. 1916, pp. 377 83, and other papers.

the roots, after the style of "kikuya grass," 3 to 6 feet apart; found of value in Rhodesia, where it is said to be one of the best grazing grasses. Thrives in moist or more or less swampy soil and in the neighbourhood of river banks. "Kikuya Grass."

Saccharum officinarum, "Sugar Cane"; the tops are often used for fodder; the molasses (the liquid remaining after separation of the sugar crystals) mixed with other suitable substances—crushed sugar-cane or "megasse" (sold as "Molascuit") and sphagnum moss (sold as "Molassine")—is a recognised cattle feed. A variety, "Uba," a thin greenish cane with long joints and hard rind, grown for sugar in Natal, Madeira, Mozambique, &c., is sometimes recommended to be grown entirely as a fodder plant, especially in the uplands, where growing cane for sugar is less profitable than at lower altitudes in the tropics; there the thick-caned varieties would be more suitable. "Sugar Cane." Patent cattle foods. "Uba" cane.

Amphilophis pertusa, Stapf. (*Andropogon pertusus*), "Sour Grass"; native of tropical Africa, India, Ceylon, Mauritius, Jamaica, &c. A perennial, propagated by division of the roots; it stands drought well. An important fodder grass in the plains of N. India, both for grazing and for hay. "Sour Grass."

Themeda quadrivalvis, "Kangaroo Grass" of Australia; native of India, found in tropical Africa; valued in India and Australia as a fodder plant. *Themeda triandra*, "Rooi Grass" of South Africa; widely distributed in tropical Africa, also in India, Malaya and Australia. A perennial, 1 to 4 feet high, densely tufted, good for cut forage and hay; recommended to be cut before the seed-heads turn brown; suitable for the drier regions, but soil requires to be good and well drained. "Kangaroo Grass."

Digitaria longiflora (*Paspalum longiflorum*); indigenous to tropical Africa, India, Malaya, &c. A perennial with slender stems ½ to 1 foot high, arising from a prostrate rooting base; recommended as a pasture plant in Ceylon, where at Peradeniya it is also regarded as an excellent lawn grass.

"Shama Millet."

Echinochloa (*Panicum*) *colona*, "Shama Millet" of India; widely spread in tropical Africa and many warm countries. An annual, growing in small tufts up to 2 feet high; thrives in rich soil and is liked by all kinds of stock. *Echinochloa pyramidalis*, a perennial up to 15 feet high, growing in water, found in rivers—Nile, Nairobi and Libet (Lake Chad) in tropical Africa; much relished by animals in the French Sudan, often cultivated. *Echinochloa stagnina*, a perennial, up to 6 feet high, with stems soft and juicy; native of tropical Africa, where it is commonly found in inundated areas of the Niger River, Lake Chad, Nile River, &c., sometimes blocking streams and waterways; said to be one of the richest fodder plants and much relished by stock.

Rhodesian "Timothy."

Setaria aurea, a perennial 5 feet high; native of tropical Africa, where it is widely distributed in Savannah areas; said to be a good hay and pasture grass. In Rhodesia it is called "Timothy."

"Italian" or "Foxtail" Millet.

Setaria italica, "Foxtail Millet," "Italian Millet," "Boer Manna" or "Hungarian Grass"; widely distributed in tropical countries. In Europe and America this is of importance as a forage crop, especially for cattle, but unless fed carefully it is reported to be injurious to horses if the hay is cut too late, and the seed-heads too fully developed. Being an annual it is raised from seed, of which about half a bushel will sow an acre; maturing in about two months, yield of hay 1 to 2 tons, recommended to be cut as the plants begin to bloom. In the Transvaal and Rhodesia it is called "Boer Manna." It is here a staple hay crop; but Teff," *Eragrostis abyssinica*, already mentioned, seems to be growing more in favour and may ultimately supersede it.

"Boer Manna."

"Rhodes Grass."

"Rhodes Grass" (*Chloris Gayana*); native of tropical and South Africa, introduced to Australia, Philippine Islands, S. United States, West Indies, &c. A fodder plant, valuable for hay and pasturage in the Transvaal, as a meadow grass in the S. United States, and commonly

grown in Texas for cut forage and for hay. A perennial, 3 to 5 feet high, requiring moderate rainfall and good loamy soil; but stands drought well. From 7 to 8 lbs. of seed will sow an acre broadcast, or 2 to 3 lbs. per acre when drilled. Grazing or cutting is possible after about two months, and the yield of hay may be 8 tons or more in moist soils, and 2 tons or more in drier soils. Tracy, an American writer, records the fact that nearly all "Rhodes grass" seed harvested in the United States is gathered about baling presses, barn floors, and other places where the hay (cut when the seeds begin to ripen) has been bundled, and that from 20 to 30 lbs. per ton may be obtained in this way. Allowance when sowing should be made for the chaff and trash.

"Sweet Grass."

"Sweet Grass" (*Chloris virgata*) is an annual, native of Africa, India, Burma, China, &c.; largely used for hay in the Transvaal; sometimes found as a weed.

"Goose Grass."

"Goose Grass" (*Eleusine indica*), found in the tropics of both the Old and the New Worlds. An annual plant from a few inches to 2 feet high, sometimes used for forage.

"Bareet Grass" an aquatic.

"Bareet Grass" (*Leersia hexandra*), a perennial widely spread in tropical and sub-tropical regions. It is an aquatic and thrives in swampy ground. The common name given is that under which it is known in the Philippines, where it is commonly cultivated and marketed each day, cut in a green state for horses.

Leguminous plants.

The following leguminous plants are commonly grown.

Alfalfa. *Medicago sativa.*

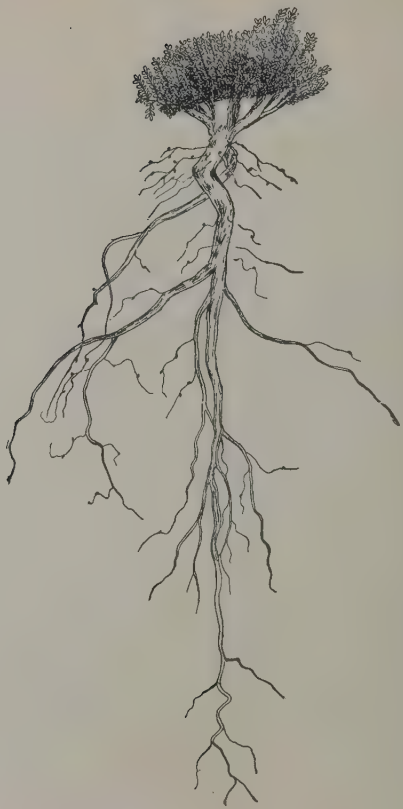
"Alfalfa" or "Lucerne" widely grown.

A perennial 1 to 2 feet high, believed to be a native of Western Asia, but widely distributed by cultivation in Europe, Asia, Africa, America and Australia, under diverse conditions of climate, including arid, semi-arid and wet regions. It seems to be generally agreed, however, that the most suitable conditions are a climate with a rainfall of from 20 to 30 inches, supplemented by irrigation; soil of unusual depth—

DRILLING ALFALFA IN A WELL-PREPARED SEED-BED.
(*From "Alfalfa Growing in the United States and Canada," by G. Stewart.*)

A WELL-DEVELOPED PLANT OF COMMON ALFALFA.

[*From "Alfalfa Growing in the United States and Canada," by G. Stewart.*



ROOT AND ROOT-CROWN OF ORDINARY ALFALFA.

[*From "Alfalfa Growing in the United States and Canada," by G. Stewart.*

well drained, open, rich and calcareous. It is important that the sub-soil be open also and of good quality. This fodder plant may be fed to all kinds of stock, used green, as hay, silage, pasture or ground into meal. The meal is the whole of the dried stems and leaves ground up, which, when mixed with grain or molasses, makes a good feed. When cut green or grazed, stock should not be allowed too much at a time—the same care as with clover at home should be exercised. Propagated by seed—10 to 20 lbs. per acre, sown broadcast or in ridges 1½ to 2 feet apart. The crop—after about three months to establish itself—will stand cutting over for many years, and the hay may be baled or stacked for future use or export. The number of cuttings and annual yield may vary according to locality, but upwards of 6 tons in several cuttings per acre may be regarded as a good yield of hay. Provence, Arabian, Turkestan and Peruvian are cultural forms of lucerne; they represent varying degrees of hardiness, the Peruvian and Arabian being the least resistant to cold and accordingly better suited to tropical countries. In general appearance both these kinds resemble the common form; though the leaves are larger and more pubescent. The Peruvian alfalfa, for instance, in the field, shows up as a silvery-green, owing to the pubescence, whilst the colour of the common form is a typical vivid green. Varieties.

On account of the rapid and almost continuous growth of the Peruvian and Arabian plants, though this meets the condition which obtains in most tropical countries of little or no real resting period, they have the disadvantage of being comparatively short-lived. It is probable there is no other forage crop so widely grown, that no country where cattle are bred on a large scale for dairying or for the production of beef can afford to be without it, and that, given suitable conditions, there is no other fodder plant to equal it in feeding value, especially when supplemented by maize, other grain, or grass hay.

Mesquit Bean, Algaroba, Honey Locust, *Prosopis juliflora.*

A deciduous tree up to 50 feet high: native of the West Indies and Central America; introduced to many countries, including Australia, South Africa, India, California, &c. The pods are good food for cattle, horses and pigs, though care is necessary to use only dried pods. It has been suggested that damp or undried pods, owing to the germination or swelling of the seed in the stomach, are dangerous and may on occasion cause death. May be propagated by seed, and when once established requires little or no cultivation, thriving in a hot climate, low rainfall and deep soil. In Hawaii, where the plant was casually introduced, it has run wild on dry scrub-lands, and become thoroughly naturalised, especially along the sea-coast, where, owing to the flowers being a good bee-food, an important trade has been developed in the island in "algaroba honey."

Pods should be well dried.

Rain Tree. *Pithecolobium Saman.*

A large deciduous tree up to 60 feet high; native of tropical America; introduced to the West Indies, India and Queensland. In Jamaica, where it is known as "guango," it has become naturalised in all the dry regions, the pods being a good fodder for stock. Propagated by seed, it grows freely in almost any situation. In Trinidad and Jamaica it is recommended as a shade tree for "Guinea grass" (*Panicum maximum*), one of the best fodder grasses described above, as well as for "cacao" (*Theobroma Cacao*). In this combination the suitable conditions of culture are indicated.

Guango pods.

Locust Bean, Carob. *Ceratonia Siliqua.*

A tree 15 to 25 feet high; native of S. Europe and the Mediterranean Region; cultivated in India, the West Indies, Queensland, &c. Thrives in a well-drained stony or calcareous soil, in a climate similar to that for the orange

or even warmer, and with a light rainfall. This tree might be considered suitable for altitudes of 3,000 or 4,000 feet in the drier regions of tropical countries. The beans are an important food for stock, and large imports to England are made from Cyprus, Portugal, Asia Minor, Algeria, Italy, &c. The broken pods in the countries of production are commonly used mixed with bran, but in this country they are largely used in the preparation of concentrated cattle foods. May be propagated by seed, which is very hard and requires soaking before sowing. Seedlings grown on in pots, in preference to nursery beds, may be planted out about 20 feet apart when about twelve months old. They are usually grafted with good varieties after another year or two, because the tree is dioecious (male and female flowers on separate trees). Trees vary as to time of commencing to fruit and yield, but a moderate estimate—beginning at three to six years with comparatively small amounts up to full production of 5 to 6 cwt. in fifteen or twenty years' time.

Locust-beans good for dry regions.

Patent cattle food.

Grafting necessary.

Velvet Bean. *Mucuna Deeringiana.*

An annual, herbaceous climbing plant, sometimes 60 feet in length, covering 18 feet or so on the ground—bush forms also exist—widely cultivated in warm countries for fodder, both in green state and as hay, the beans also being used for animals, usually ground into meal and used like cotton-seed meal. Propagated from seed, a bushel or so to an acre, sown in rows 3 feet apart each way; plants come to maturity in about five months, succeeding well in light soil. A good crop would be, of green forage, about 8 tons; hay, recommended to be cut when in flower or early pod stage, 2½ to 3½ tons; or about 20 to 25 bushels of beans per acre. A useful and profitable mixed crop, especially for green forage, is to grow bush forms with sorghum which, as indicated above, would mature about the same time and would serve the purpose of supports for the beans mean-

Bush forms of velvet bean mixed with sorghum.

FIELD OF VELVET BEANS (*Mucuna Deeringiana*).

[*From "Southern Field Crops," by J. F. Duggar.*

time, and the ultimate result in enriching the ground would be equivalent in growing clover with wheat at home.

Two other leguminous plants that are common all over the tropics are "Pigeon Pea" (*Cajanus indicus*) and "Cow Pea" (*Vignia Catiang*). "Pigeon pea" is a perennial, but is usually treated as an annual; grows about 6 or 8 feet high. Sown broadcast or in rows 4 to 6 feet apart, the plants mature in about six months; grown commonly for food, but often for forage, especially while the fruits are young and tender. The "cow pea," an annual plant, climbing upwards of 6 feet, commonly cultivated in the tropics, sub-tropics and countries with long, hot summers. Sown broadcast or in rows about 3 feet apart, it comes to maturity in from three to five months according to variety, of which there are many differing in size and colour of the seed, and in the habit of growth. In addition to the hot climate a moderate rainfall and rich soil are desirable. This is one of the standard forage crops in the Southern United States, where it is largely grown in the hot months for hay, pasture and green manure. In Queensland, when grown for green manure, it has been recommended to feed pigs on the field about the time the first peas are ripening, an acre being sufficient to pasture fifteen to twenty pigs for several weeks. In general, from 1 to 2 tons of hay and 10 to 12 bushels of grain seems to be a fair yield.

Pigeon pea.

Cow pea.

Yield.

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CHAPTER XVII

RUBBER, GUTTA PERCHA AND BALATA

THESE plants are discussed under one heading because they are usually classified together in the trade returns of the rubber market. As items of Tropical Agriculture it is only the rubber trees proper that immediately concern us, though the Gutta percha tree (*Palaquium Gutta*) has been cultivated to a limited extent on a plantation scale. Balata (*Mimusops bidentata*) so far appears to be entirely the product of wild trees, confined to the forests of Venezuela and the Guianas (British, French and Dutch); the tree grows 60 to 120 feet high, 4 to 5 feet in diameter, and it is held to be of very slow growth. It would therefore seem open to question whether the tree is ever likely to be cultivated except perhaps under forestry conditions, when the timber, which is valuable, would finally be regarded as the greater asset.

PARA RUBBER. (*Hevea brasiliensis*).

A tree native of Brazil, cultivated in many tropical countries. Our chief commercial sources of plantation rubber are Federated Malay States and Ceylon in British Possessions, and Dutch East Indies. Propagated from seed, which should be specially selected from trees known to be good yielders of latex. It is advisable to sow in nursery beds as soon as possible, as the seeds lose their vitality within two or three weeks; they germinate in a few days and may be ready for transplanting to permanent places when 2 feet or so high, or about six to nine months

Propagation.

PARA RUBBER PLANTATION, GOLD COAST.

The trees are now almost, if not quite, obsolete; and the trees require more space than as here shown.

TYPES OF TAPPING KNIVES IN USE IN THE EAST.

(*a*) Farrier. (*b*) Jebong. (*c*) Improved Straight Gouge. (*d*) "XL."

[*By courtesy of Messrs. David Bridge & Co., Ltd.*

old. Sometimes the seedlings are allowed to grow on until about 6 feet high, when they are topped and trimmed to so-called "stumps" which are sometimes sold for the foundation of plantations. Planting seed at stake (or direct into permanent places) is sometimes practised; plants may also be raised by asexual methods—cuttings, budding and grafting—but of these methods, propagation of good latex-yielding trees by budding and grafting is only in the experimental stage. In the plantation trees for full development require to be from 20 to 30 feet apart, and it is a matter of choice to plant about half the distance and thin out as the trees develop, or plant at the full distance and grow in the meantime catch crops—such as Robusta coffee, castor oil plant, capsicums or peppers, pine-apple, bananas, lemon grass, &c.

Catch crops.

Tapping may begin when four to seven years old or when the trees are not less than 6 to 8 inches in diameter at 3 feet from the ground. The limit in the trunk for tapping was formerly about 5 feet, but nowadays 2 to 3 feet from the base is recommended. The methods of tapping have varied considerably from time to time, the original being numerous V-shaped cuts with small collecting vessels at the base of each—a slight improvement on the native methods in the Amazon—spiral, herring-bone and vertical incisions, all of which now appear to be more or less obsolete. A basal V beginning over about half the circumference, and a modified herring-bone system, are now in favour. The first system may occupy about five years, by tapping on alternate days and using up approximately three-quarters of an inch of bark per month—each shaving about 1 mm. thick—over an area of 20 inches or so from the ground-line. The last mentioned would mean lateral incisions 12 to 18 inches apart on one side of the vertical line only at one time, usually the left, at an angle of about 45°, one-quarter or one-third only being taken in hand at one time, the tappings being calculated to cover the section in one to two years, and the circumference

Tapping.

TAPPING PARA RUBBER.

Basal V, the method now in favour, showing tapping gouge and glass cup.

[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

NATIVES COLLECTING LATEX FROM "PARA-RUBBER" TREES (*Hevea brasiliensis*)
IN THE FEDERATED MALAY STATES

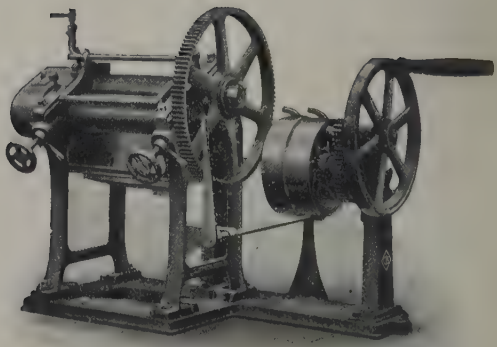
in four to six years, when the bark on the first section tapped should be sufficiently renewed to admit of a repetition of the process. There is a strong tendency now to regulate the tappings in order to cover the regulation area of the trunk in eight years or more. Other systems are adapted to conditions ruling on various estates, such as tapping trees on certain sections, each day from three to six months and resting for a similar period, or resting say 25 per cent. and tapping 75 per cent. of the trees in divided areas of the estate. The ideal system is one that conserves labour, produces an economical yield and preserves the life of the tree over a working period of from thirty to thirty-five years or thereabouts.

Tapping knives.

Tapping knives vary, but perhaps more depends on the skill of the workmen, who as a rule prefer as simple a tool as possible, like the ordinary gouge chisel $\frac{1}{4}$ to $\frac{1}{2}$ inch wide —commonly used in the Federated Malay States and Straits Settlements. There are several patents on the market, each one effective, but requiring skilful handling. The main point is to be careful not to cut so deeply into the bark as to injure the wood or cambium layer. Farrier knives were used in the early stages, but the gouge and a tool known as "Jebong," the patterns "Serdang" and "Kuala," being now preferred on most plantations in the East.

Collecting latex and coagulation.

Collecting vessels or cups are usually recommended to be made of glass or smooth earthenware or of a material that can be cleaned easily. These appear to have now superseded the coco-nut, tin or iron of the early days of the industry, and probably also the aluminium and enamelled iron which have had their turn. Small galvanised spouts inserted into the bark are used for conveying the latex into the cups. Enamelled buckets or ordinary galvanised milk-pails or tin-plate cans for carrying the latex to the factory are commonly used, though kerosene tins were at first employed, largely on account of their cheapness and convenience in handling. Coagulation may be effected by

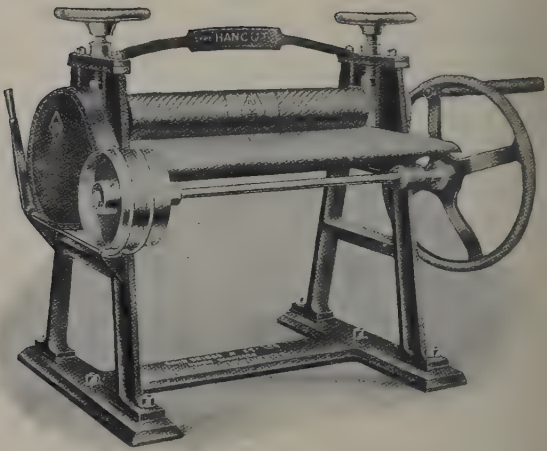


MACHINE FOR MAKING SHEET OR CRÊPE RUBBER (TYPE "DIMAR").

Belt driven and for hand power.

RUBBER SHEETING AND MARKING MACHINE (TYPE "HANPUL").

Combined hand and power, $4\frac{1}{2}$ ins. $\times$ 24 ins., with smooth rolls, for rolling out evenly the newly coagulated latex into plain sheet.



RUBBER SHEETING AND MARKING MACHINE (TYPE "HANCUT").

Combined hand and power, $4\frac{1}{2}$ ins. × 24 ins., with cut rolls (ribbed, diamond or spiral) for marking the newly rolled out latex.

VIEW INSIDE A RUBBER FACTORY IN THE FEDERATED MALAY STATES.

Showing a battery of macerating, sheeting and crêpeing machines together with scrap washer.

[*By courtesy of Messrs. David Bridge & Co., Ltd.*

Rubber sheeting and marking machinery (see pp. 488–90).

various acids, acetic diluted with water being the one most commonly used. This is usually done in enamelled pans, the coagulum afterwards being made into sheets, which are rolled out by hand or put through rollers of a machine to press firm, and usually to give some characteristic design or mark of the estate where grown. Methods have been patented of coagulation by specially designed machinery, on the native Brazilian principle—that is, of submitting to the smoke of burning nuts. Whatever method of coagulating is adopted, it is important that the prepared product be thoroughly dry before packing for shipment. Smoke drying instead of air drying is sometimes resorted to, the fuel being mangrove wood, coco-nut husks, or other convenient material.

Commercial forms of prepared rubber.

The principal forms of prepared rubber now in favour in the trade are indicated by the market returns, which (August 1926) show Plantation rubber—"Crêpe," 1*s.* 6*d.* to 1*s.* 7*d.* per lb., and "Ribbed Smoked Sheet" 1*s.* 7*d.* per lb.; "Hard Fine Para" is the market description for native prepared Brazilian—about same value.

The total production for a year of plantation rubber is estimated at more than 500,000 tons against about 40,000 to 50,000 tons of wild rubber. Latex is now exported from Malaya (over 2,000,000 galls. in 1926), Ceylon and Sumatra.

Ceara Rubber. *Manihot Glaziovii.*

A tree growing to a height of 30 to 50 feet, 1 to 1½ feet in diameter; native of Brazil, where it grows chiefly in the province of Ceara. It has been cultivated probably all over the drier regions of the tropics, including every British Colony, plants being first sent out from Kew to Calcutta, Singapore and Ceylon in 1877. The tree is easily grown from seeds or cuttings. The seeds require soaking in water or filing before sowing, to hasten germination. A good plan is to sow in permanent places, as, where germination is good, the plants grow so quickly that they would soon get out of hand for transplanting if raised in a nursery.

Propagation.

A distance of about 10 to 20 feet should be allowed between each tree, and catch crops or cover plants are not as a rule necessary, except, perhaps, in the early years of the plantation. A hot, dry climate is essential to rubber production, the yield of which may be estimated at about 25 grammes per tree in about the third and fourth year, and 125 grammes and upwards afterwards. Tapping may be done as advised for *Hevea*, but it is first necessary to peel off the outer bark, and as the latex coagulates almost immediately on exposure, it is necessary to delay this by trickling water, or water containing ammonia, on to the cut surfaces, so that the latex may be collected at the foot of the vertical incisions and treated in the ordinary way. A method of tapping found successful in Tanganyika is that known as the "Lewa" method. It consists of cleaning portions of the cortex by the removal of pieces of bark and then painting over with dilute acetic, citric or carbolic acid; point-like incisions are made in the bark, and as the latex flows and coagulates on the tree in thin tears of rubber, it is collected and worked up into round balls. The tree grows freely almost anywhere in the tropics, but, as already stated, the condition must be dry to produce rubber, and as a consequence the yield has in most places been very disappointing, and the tree regarded as a failure. It is probable that Tanganyika is the most successful country of production, or where the trade has become of any importance up to the present time. Another cause of failure is that there appears to be good and bad Cearas, and it is recommended that if, on testing, any young tree before it is two years old is found to yield a thin watery latex, it should be cut out and replaced by one giving a thicker and more profitable latex. The above *Manihot* is known also as "manicoba," and there are two other species also known under the same name to which the same general information would in the main apply—*Manihot dichotoma*, the "Jequie manicoba," a tree 10 to 14 feet high, and *M.*

Tapping.

"Lewa" method of tapping.

Other species of manicoba rubber.

PLANTATION OF PARA RUBBER AND CENTRAL AMERICAN RUBBER TREES, 7 YEARS OLD, TRINIDAD.
[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

piauhyensis, the "Piauhy manicoba," a tree 6 to 16 feet high, both natives of Brazil, and both yield good rubber; but so far do not appear to be so widely spread under cultivation.

CENTRAL AMERICAN RUBBER TREE. *Castilloa elastica.*

A tree 60 feet high and upwards, native of Mexico, cultivated in many tropical countries. May be raised from seed—which soon loses its vitality—in nursery beds, in bamboo pots or sown at stake, and as soon as large enough to transplant—a foot or so high—each plant should be put out in the plantation at distances of from 18 to 20 feet. Good drainage and a loamy soil are desirable, and as the tree is one that does not like too much sunlight on the trunk, some undergrowth or catch crop should be used for shade until the tree develops a good head large enough to form a shade. There appears to be no method of tapping this tree approaching the perfection of that in use for *Hevea*. The tapping of forest-grown trees is effected by cutting them down and ringing the bark at convenient distances along the trunk. On some Mexican plantations large V incisions are made, whilst in Trinidad it has been found that the most profitable way is by tapping in dry weather, with a cutlass, two or three times a year, allowing the latex to coagulate on the tree and collecting it four days after cutting, in the form of "scrap-ball." Before beginning to tap, it is recommended that the trunk should be 12 ins. in diameter, 40 to 45 feet high, or about nine to ten years old, and that the cuts be made about one foot apart, obliquely in an upward direction and on one side of the tree only. The latex coagulates readily, but sometimes the natives make a decoction of the "moon-plant" (*Calonyction speciosum*), by pounding the stems in a bucket of water, straining and adding one pint to a gallon of the rubber milk, stirring until the whole of the milk is coagulated. The floating rubber is then strained off and kneaded into cakes, the

Propagation.

Tapping.

Coagulation of latex.

water pressed out, then dried and packed for export. The rubber collects like cream when the latex is diluted with hot water, when it may be made into sheets like that of *Hevea*, while a centrifugal machine, ordinary evaporation and coagulants, as alum or others of an alkaline character, may also be used. The yield may vary, but 1 lb. of rubber per annum for each tree nine to ten years old is given as a good average. Some uncertainty, however, as to the value of this tree for cultivation for rubber production seems to have arisen of late. It has been recommended as a shade or shelter tree for coffee, cocoa, &c., because of its being a deep rooter. In Trinidad the Rubber Committee of the Board of Agriculture a few years ago came to the conclusion that "the planting of *Castilloa* as a pure crop is not profitable anywhere," but where it "has already been established and makes vigorous growth it will pay to tap it." Opinions have been advanced giving no encouragement whatever for the cultivation of this tree, but without going so far as this it would seen advisable not to rely on it, especially where it may be just as convenient to grow Para rubber. The principal trade sources of the rubber are British Honduras, Nicaragua, Guatemala, Mexico and Ecuador.

Castilloa as a shade tree or wind-break.

Trade sources of *Castilloa* rubber.

Assam Rubber. *Ficus elastica.*

A large evergreen tree 100 feet and upwards; native of Assam; cultivated in India, Ceylon, East Indies, West Indies and tropical Africa. May be propagated by seed, which is very small—about 270,000 calculated to the pound—and when quite fresh germinates in a week or fourteen days, but reported sometimes to take three months to germinate. Cuttings (a foot or two in length) root freely and soon make good plants. Having regard to the size of the tree when mature, from 30 to 50 feet space between each one should be allowed when transplanting to permanent places. Tapping cannot be effected in the ordinary way: the rubber is extracted by making gashes in the bark from

Propagation.

Tapping.

which the latex flows and coagulates on the tree, and when collected a lump has the appearance of "scrap rubber" or "Ceara." In India the trees are reported to be liable to die if tapped yearly, and once in three years is considered enough. The yield has not been so satisfactory from trees grown in the plains as from those in the hills, under conditions which approach more nearly to those of its native habitat, where it is found as an epiphyte. It grows freely enough anywhere in a hot, steamy climate, in well-drained soil or under conditions ideal for *Hevea;* but in comparison the yield is unsatisfactory, and as the *Ficus* does not so readily lend itself to tapping, these objections may, on the whole, account for the disfavour into which it appears to have fallen under cultivation. In Sumatra and Java, where plantations were established in 1872, perhaps the only countries that have shipped regular supplies of the rubber from cultivated as well as from wild trees, the plants are being cut out in the majority of estates and replaced by those of Para rubber. Apart from any other consideration, however, *Ficus elastica* is well worth growing for ornament and shade, and it may be useful to cultivate it as an adjunct to some more profitable industry, such as tea culture or on somewhat the same principle as suggested for *Castilloa.*

Hot, moist climate required.

This is the main source of "Assam rubber" obtained chiefly from wild plants and, as indicated above, before the introduction of Para rubber also the most important source of rubber from Java and Sumatra.

Trade sources of Assam rubber.

WEST AFRICAN TREE RUBBER. *Funtumia elastica.*

A tree 25 to 50 feet high; native of West Tropical Africa. Propagation is easy from seeds, and it may be raised from cuttings, but it is better to rely on the former. After flowering the follicles develop and ripen in six to eight months. A single follicle contains about 60 seeds easily detachable from the floss, and in an ounce there are about 800. Sow as early as possible after collection in shallow,

Propagation.

well-drained boxes, or in nursery beds in light, rich soil, from an inch to 2 inches apart, and when about 3 or 4 inches high they may be transplanted into prepared beds and given a foot or so between each plant, or better to put them singly into bamboo pots. It is important to keep the young plants growing without a check until strong enough—about six months after sowing—for putting out in permanent places, where they should be given distances of 15 to 20 feet apart.

Catch crops. A catch crop like ground nut (*Arachis hypogæa*) or some other suitable leguminous cover crop should be grown to keep the ground in good tilth, until the trees are large enough to tap, or they are large enough to cover the ground.

Tapping on same lines as for *Hevea*. Tapping may be done on much the same principle as for *Hevea*, but generally on the herring-bone system. The official regulations in West Africa have been to the effect that no tree should be tapped higher than 10 feet from the ground, which has not a girth of at least 18 ins., except on the full herring-bone system, nor be tapped at a later hour than 8 a.m., and not more than once a year. In the system advised, a channel is cut from the base to the authorised height on the trunk, with side grooves at intervals of not less than 6 ins. and not more than $\frac{1}{4}$ in. wide, and, as with *Hevea*, special care being taken not to cut into the wood or cambium layer, and not more than half the tree to be tapped at one time.

Tapping tools. For tapping, the ordinary gouge chisel $\frac{1}{4}$ in. wide is favoured, but patent tools as for *Hevea* have at times been recommended and used.

Coagulation of latex. The coagulation and preparation of the rubber may be effected by the same methods as recommended for Para rubber. The yield varies according to age and locality, but from 1 to 4 ozs. from trees about seven years old is believed to be a fair estimate. When the tree was first discovered the native methods produced from 10 to 15 lbs. per tree, but this meant bleeding them to death, and the industry soon began to show signs of giving out, when official control was organised. This is the most important source of rubber in West Africa; supplies also come from

Uganda, where, in the forests, the tree was discovered some years ago. It comes into the market from forest sources as "lump" rubber from Lagos, Gold Coast and Ivory Coast; "Manoh cubes" from the Ivory Coast, "Manoh twist" from Sierra Leone, &c., the prices ruling in Nov. 1926 being about 1*s.* 3*d.* per lb. The price of "Plantation Funtumia" compares very favourably with that of Para rubber, which was quoted in Nov. 1926 at about 1*s.* 10*d.* per lb. Trade forms of Funtumia rubber.

It remains only to mention the *Landolphia* rubbers, all from various parts of tropical Africa, from whence also come trade products obtained from other genera belonging to the same family (*Apocynaceæ*), which includes species of *Clitandra* and *Carpodinus*. These, however, do not lend themselves to cultivation, being chiefly large climbers or low-growing plants with rhizomes. The cultivation of some of the Landolphias has been tried on a plantation scale, but so far all the rubber coming into the market appears to be from wild sources. Rubber from *Landolphia* and other genera of the Family *Apocynaceæ*.

Gutta Percha. *Palaquium Gutta.*

A tree 100 to 200 feet high, 4 to 5 feet in diameter when fully grown, with buttresses 6 to 8 feet high, extending at the base 4 to 5 feet from the trunk. Native of Malaya, cultivated in the Straits Settlements, Java, &c. Plants may be propagated from fresh seeds, raised in nursery beds or in bamboo pots; they may be transplanted to permanent places when about a foot or so high at from 12 to 15 or 20 feet apart. The tree requires continual moisture, and the main requirements are, accordingly, moist but well-drained rich loamy soil, good rainfall and an average temperature of about 80° F. Tapping is recommended to commence when the trees are ten years old. The methods of tapping may be regarded as similar to those for Para rubber or as given under *Funtumia*. The native method is the same as that for *Castilloa* in America—cutting down the trees and ringing Propagation.

Tree of slow growth.

them. The growth is comparatively slow. It has been estimated[1] on the annual rate of growth—in some instances 1·69 inches—of forest trees in the Malay States, that it takes about forty years to reach a girth of six feet at six feet from the ground. In other cases the rate of increase has varied from three to twenty-four inches in seven years, the girth increment becoming greater as the crown of the tree reaches the light. The tree, according to one report,[2] does not begin to flower until twenty-eight or thirty years of age, and when mature the trunk is about three feet in circumference at about five feet from the ground. A tree sent out from Kew, planted at Old Calabar in August 1900, is reported to have flowered in January 1909.

Yield variable.

Estimates of the yield of gutta percha are very variable—100 grammes or nearly one fifth of a lb. per tree at fifteen to seventeen years old (Sherman); 2 lb. 5 ozs. from a tree at least 100 years old (Wray); 11 ozs. from adult trees in West Sumatra (Burck); 2 to 3 lbs. from a well-grown tree, and 50 or 60 lbs. from trees 100 to 140 feet high (Collins). Trees thirty to thirty-five years old are said to yield 2 to 3 lbs. of gutta under the destructive native method of tapping (Gamble). The foregoing refer to extract from the trunk, but it is possible to obtain a substantial amount of gutta percha from the green and dry leaves, an advantage that cannot be advanced in favour of any of the rubber trees or balata. There are two processes—the mechanical and the chemical—by which it may be recovered from the leaves and young branches. In the mechanical, the dry leaves are ground to powder, after being moistened with hot water; the powder is then washed in tanks of water until the gutta floats, when it is collected and afterwards pressed and moulded in warm water. In the chemical process the gutta is extracted from the powdered leaves by means of a

Gutta obtained both from leaves and trunk.

[1] Burn-Murdoch, Agric. Bull., Straits Settlements, Sept. 1908, p. 389.

[2] Sérullas, "Some Facts Concerning Gutta-Percha," p. 5.

volatile solvent, such as carbon-bisulphide. It is recommended as better to treat the leaves while green and by other than chemical processes, in order to avoid oxidation and changes in structure, and extraction from the leaves is regarded as being more profitable than tapping. Gutta percha realises at the present time (1928) about 1*s.* 3*d.* per lb. It is imported chiefly from the Straits Settlements, Federated Malay States, Java and Sumatra.

Market price.

Our own Customs returns show imports of gutta percha with those of balata obviously included ; but it may safely be stated that the returns from British Guiana, Venezuela or any South American country are entirely those of balata.

Gutta percha is largely used for insulating telegraph and telephone wires, and, being durable under water, is indispensable for insulating deep-sea cables; other uses are in the manufacture of golf-balls, waterproof soles for boots, &c.

Uses.

It will be seen that this chapter deals with trees requiring to be planted at substantial distances apart, and as with coffee (see p. 124) the former practice of clean weeding is now almost invariably condemned, in all cases demanding the use of green manure plants or suitable cover crops to prevent soil wash. Where the ground is naturally level this may be effected with comparatively little trouble, but on sloping ground the matter of erosion becomes more serious. It has brought into practice on some estates a system of soil terraces or buttresses, arranged in a series of contour lines, about 20 feet apart, each terrace or platform being not less than 6 feet deep, running through the plantation, on which the trees with cover plants—preferably leguminous (see p. 59)—are grown. The buttresses of soil are built up by degrees on the margins of the terrace-like platforms after the trees are planted on the contours, the soil on the surface of the embankments being planted with cover plants in the same way.

Contour terraces and buttresses.

The above remarks refer more particularly to "Para rubber" (*Hevea brasiliensis*) since it is with this tree, on

plantations in Malaya and the East, that experiments and research have been productive of the best results.

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CHAPTER XVIII

FIBRES

It is proposed to deal here with fibres that are of commercial importance only, which are comparatively limited amongst the many that could be mentioned, and still further limited when it is desired to confine the chapter to those produced in tropical countries under agricultural conditions. It is convenient to separate them into "seed-hair fibres," "leaf fibres," "stem or bast fibres," and "general."

The seed-hair fibres are "cotton," "kapok" and "akund." Seed-hair fibres.

Cotton. *Gossypium* spp.

The cotton of commerce is obtained from several widely differing species of the genus *Gossypium*, and in dealing with this one is dealing with at least four distinct crops. Commercial cottons.

1. American Upland Cotton.—This is generally considered to belong to cultivated races of *Gossypium hirsutum* and closely allied species. Cotton of this type also grows in Cambodia, and from there has spread fairly extensively to the warmer parts of India, and still more recently has been introduced into Africa, where its capacity for resisting the attacks of "jassid" should make it particularly valuable. American Upland cotton has also been introduced as a rain-fed crop into many parts of Africa within this century, and is the main type under cultivation not only in the British possessions, but also in French and Belgian territory. Its spread has not been rapid, as many difficulties have been experienced in finding and producing types

Cultivated races of *Gossypium hirsutum*.

American Upland cotton in Africa.

which are suited to the changed conditions from those for which varieties had been evolved in the U.S.A. This type is also under cultivation in Asiatic Russia, Brazil, Queensland and the irrigated tracts of the Punjab.

Grown as an annual.

Ratoon crop.

As a crop it is treated as an annual, though in warm countries the perennial habit has made it possible to grow it as a "ratoon" crop. Such a method has, however, been banned in most countries owing to the prevalence of insect pests, which can in this way be carried over from one season to another.

SOILS.—This type of cotton will thrive on most classes of soil, though in dry countries heavy soils are uncertain. Such soils are liable to crack deeply in dry weather, and as Upland cotton develops strong side roots at no great distance from the surface, not only are these roots subjected to drought when the land cracks, but they are very liable to be injured. In a more temperate climate with a well-distributed rainfall, such as that experienced in the Texas area of the U.S.A., cotton thrives very well on this type of land. Provided the lands are fertile, plants should be more widely spaced on the lighter classes of soil, as under such conditions there is much stronger root development with consequent increased vegetative growth.

The soil in relation to root development.

Light rainfall desirable.

CLIMATE.—Upland cotton does not require a heavy rainfall and, if well distributed, 20 inches of rain during the growing season is ample to secure a crop. Heavy rains during the growing season tend on light loams to cause excessive vegetative growth, while on heavy lands growth may be checked entirely. The various species of bollworm which occur in every cotton-growing country are likely to do very much more damage in seasons of heavy rainfall, and have been known to destroy the crop entirely. Very dry weather and atmospheric conditions are also inimical, and for such areas special strains of cotton, in which the hirsute characters of the leaves are specially well developed, have to be produced. In the first half of last century the East India

Destruction of crop by bollworm.

Special strains of *G. hirsutum* for dry climates.

Company made great efforts to introduce this kind of cotton into India, but the only place where it has survived as a rain-fed crop is in the Dharwar district, which is situated on the Deccan plateau, where the air is kept cool and moist by the S.W. monsoon. Upland cotton in India.

CULTIVATION.—Cotton being an extensively rather than an intensively cultivated crop, the land does not always receive that amount of cultivation which is required to bring in the greatest profit, but this defect is now being realised and it is becoming more and more the practice to plough the whole land instead of merely ploughing or digging along the lines where the seed is to be sown. In addition to ploughing it is essential to have a firm seed-bed. In some countries the rainfall before sowing is sufficient to form this, but in Africa especially, where advantage has often to be taken of the first sowing rains if the crop is to have the full benefit of the season, harrowing and breaking down the clods is often a necessary part of the preliminary cultivation. Thorough ploughing, harrowing and rolling before sowing.

The cotton seed is sown in rows. These are spaced from three to five feet apart according to the quality of the land and the rainfall which is expected. As already mentioned, where there is a heavy rainfall and a free-working soil wider spacing is necessary. The seed is sown with a drill or planter in countries where animal draught is available, but where human agency has to be employed the seed is sown with a hoe along lines which are previously set out. The seed rate is usually about 20 lbs. per acre, though a less quantity is sufficient where the seed-bed is good and the moisture for germination is ample. The depth at which the seed is sown is also a matter for consideration. Upland cotton has a fuzzy seed. If further rain is expected, the seed should not be covered too deep, otherwise there is a danger that it will rot, while if dry weather follows sowing there may not be sufficient moisture near the surface unless the seed is covered fairly deeply. It is here that the farmer must use his judgment, and he should always be prepared Spacing of the seed. Cotton planter (see p. 48). Quantity of seed to sow an acre. Depth of sowing seed.

by having a larger supply of seed than he actually requires in case the field has to be resown.

Sowing on ridges and level ground.

In some places cotton is sown on slight ridges and in others it is sown on the flat ground. This variation in practice is largely a matter of climate. A slight ridge improves the surface drainage, and where heavy rains are likely to be experienced while the plant is making its main vegetative growth, this will stimulate growth and early maturity. Where the rainfall is light and moisture conservation is likely to be necessary during the period of growth there is an advantage in planting on the flat.

Thinning out seedlings.

AFTER CULTIVATION.—When the crop has made three or four leaves it is necessary to thin out the plants so that they are not too crowded in the row. The spacing in the row depends again on the soil, rainfall and climate, and it is a matter for experiment to find out the correct distance in any given locality. Spacings from nine inches to two feet are practised in different countries, and in America recently even closer planting has been recommended in some States in order to check vegetative growth, and thus to force the plant to early maturity in order to prevent insect damage.

Cultivation between the rows.

Frequent surface cultivation between the rows is necessary; this is of special importance in countries where there is a danger of insufficient soil moisture at the time when the bolls are swelling.

MANURING.—This is a subject on which information is required. In the U.S.A. manuring is now largely practised, but this is owing to the damage done to late-maturing crops by the boll weevil. There, the idea behind manuring is to force the crop to early maturity so as to avoid the main damage caused by this pest. For this purpose nitrogenous manures are recommended, such as nitrate of soda and sulphate of ammonia, to be applied as top-dressings during the early stages of growth. Phosphatic manures are also applied, as these also tend to cause early and uniform ripening of the bolls.

Nitrogenous manures.

Phosphatic manures.

HARVESTING.—When the cotton fruit or boll is ripe it bursts open and the seed cotton within expands. In fine weather it may remain in this condition on the plants for several days, until sufficient is open to make picking economical. The picker is furnished with a long cotton bag which is slung over one shoulder in such a way that the mouth is conveniently placed for stuffing in the picked cotton. The locks of seed cotton which now hang out of the open boll are all picked together with a slight jerk to liberate these from the boll, one or both hands being employed. The method of picking depends on the type of gin used. Where these are fitted with hullers or cleaning apparatus to remove leaf, &c. before the cotton is ginned, not so much care is required to see that the seed cotton is picked clean, but where roller gins or saw gins not so fitted are employed, much more care must be taken, and cotton is then picked only with one hand, the other being used to pick off broken leaf, &c. before placing it in the bag. It is an advantage to commence picking as early in the day as possible, while the dry leaf on the maturing plant is still soft with dew, and not likely to break into the cotton. In many countries, especially where damage had been caused by bollworm, it it advisable to hand sort the seed cotton to remove any which is damaged or stained, as the presence of such in the sample greatly lowers its market value, producing as it does discoloration or "stain" in the ginned sample.

Method of picking.

Ginning machines (see pp. 5 to 6–8).

Early morning picking the best.

2. INDIAN COTTONS.—The main crops of Indian cotton belong to the three species: *Gossypium neglectum*, *G. indicum* and *G. herbaceum*. Though perennial in habit all of these are cultivated as annual crops. They differ greatly from the American cotton in size, appearance, root habit and size of boll. The cotton also is of different quality, generally being coarser, stronger and usually having a shorter staple. As regards root habit, the Indian cottons have a long, slender tap-root which penetrates deeply into the ground. The main lateral roots, instead of running near the surface of

Perennial cottons grown as annuals.

Root habit.

the soil, also penetrate deeply, going down at an acute angle. This habit is, however, liable to be influenced by rainfall and manuring, and for this reason in dry districts cotton land is never heavily manured, as it is essential that the root system should be able to feed deep down where moisture is to be found.

Main cotton districts of India. "Black cotton soils."

The main cotton districts of India are situated in country where the "black cotton soils" occur. These are heavy soils, often very deep, which crack badly when dry and swell and loosen up well after a rain. Similar soil occurs throughout the tropics and sub-tropics, especially in localities of low rainfall. The black soils of Texas, the "vlei" lands of South Africa and the soils around Lake Chad are of this type. *Gossypium herbaceum* is essentially a crop for this type of soil and is the most drought-resistant of all the Indian cottons. Varieties of the other two species, though largely grown on this type of soil, are more adaptable to lighter soils.

Soils of Texas, S. Africa and Central Africa.

Indian cottons thrive under low rainfall.

CLIMATE.—Indian cottons are essentially crops of the drier parts of India, and they thrive in districts where the rainfall during the growing season is as low as 10 inches, though in many of the cotton districts the rainfall is higher than this. In most parts of India the crop is sown in June and July at the commencement of the S.W. monsoon. These rains decline in August, and after that the weather is generally quite dry. In the south, where the Western Ghats cut off the rains of the S.W. monsoon, the sowing season does not begin until the much more precarious N.E. monsoon sets in, in October–November.

Period of sowing.

CULTIVATION.—The custom of the country varies considerably with the depth of the soil. Where this is very deep and has cracked thoroughly in the dry weather it is not the custom generally to plough except at intervals of three or four years. It is considered that the cracking of the soil and the lifting of the surface soil after the first rains are received, are sufficient, and under such conditions a blade

Preparation of the surface soil by means of a cultivator.

cultivator is worked over the land to level and loosen the surface and to cut off any weeds which have survived the hot weather. Where the soils are shallow, and where they have not cracked deeply, the land is generally ploughed as soon as a rain has made the soil sufficiently soft for the ploughs to enter. Dry ploughing is occasionally done with heavy ploughs, but it is difficult to consolidate the soil and get a firm seed-bed if this is done.

Manuring depends on rainfall.

MANURING.—This depends on the rainfall. In districts liable to drought, applying manure direct to the cotton crop is not practised, since the plant is then liable to make so much vegetative growth that it cannot mature its crop. On such land, if manure is to be given it is applied to a previous grain crop in the rotation. Where the soil is not liable to crack, a light manuring is sometimes given, usually by folding sheep and goats, while in some districts where there is not so much fear of drought, nitrogenous manures, such as sulphate of ammonia, are recommended.

Seed rate per acre.

SOWING.—The seed rate for cotton varies from five to twenty pounds per acre. In very precarious districts the crop is purposely sown thick and is not thinned afterwards. This is done with the object of forcing the crop to early maturity, so that it will not be unduly affected by prolonged dry weather. In other places where the seed is sown broadcast and ploughed in, a heavier seed rate is necessary. In most places, however, the seed is sown with the native two-tined bamboo tube drill and the rows are spaced about eighteen inches apart. In precarious districts cotton is very often grown as a mixed crop, which is the usual method of crop insurance. If this is done the cotton rows are spaced up to thirty inches apart with two rows of some small-growing cereal between each two rows of cotton. Such crops as *Setaria italica*, *Panicum miliaceum*, *Paspalum scrobiculatum* and dry-land rice being used.

Spacing of rows.

Mixed crops.

After cultivation consists of working small-blade hoes drawn by cattle between the rows of the cotton, or between

the rows of the mixed cotton and cereal. Hand-weeding is done between the plants in the rows and, where climatic conditions permit, the plants are thinned out to the requisite spacing, which is usually about nine inches to a foot apart. This inter-cultivation is continued at intervals until the crop commences to swell its bolls, or even later if weather conditions are very dry.

Thinning out seedlings.

Crop matures in 4 to 4½ months.

HARVESTING.—Picking commences some four to four and a half months after sowing, and the general practice is to pick at short intervals. This is more necessary in India, because of the dry weather conditions which prevail as the crop ripens, when the fields are full of fallen leaf, and small whirlwinds which soil the cotton are frequent. The quantity picked by each worker is much smaller, therefore, than in the case of Upland cotton, not only because there is not so much of the crop ready for picking at any one time, but because the fruit or boll of the Indian cotton is very much smaller. Since the roller gin is so generally used in India clean picking is essential. The average acre yields of cotton in India are about one-third of that obtained in the U.S.A., but this is hardly to be wondered at when the adverse conditions, under which so much of the Indian crop is produced, are considered. Under favourable conditions and good farming, yields of half to two-thirds of a bale per acre are by no means uncommon.

Roller gin in general use in India

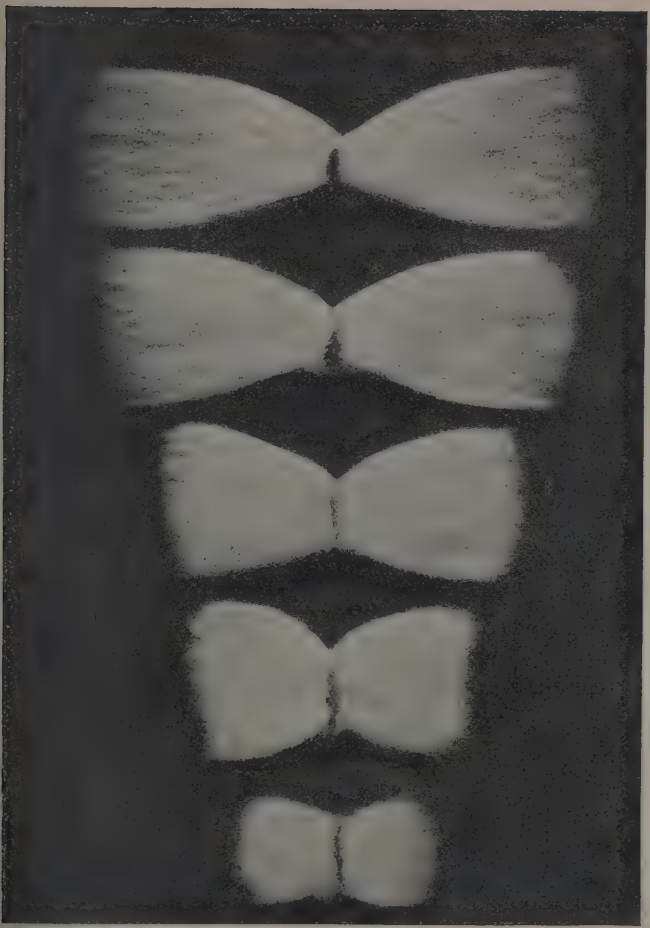
Yield per acre.

Proportion of lint to seed.

The ginning percentage of Indian cotton is very variable and may range from 24 to 42 per cent of lint to seed according to variety. Within recent years much improvement has been made by selection and breeding to raise this percentage as well as to improve the staple.

New World cottons.

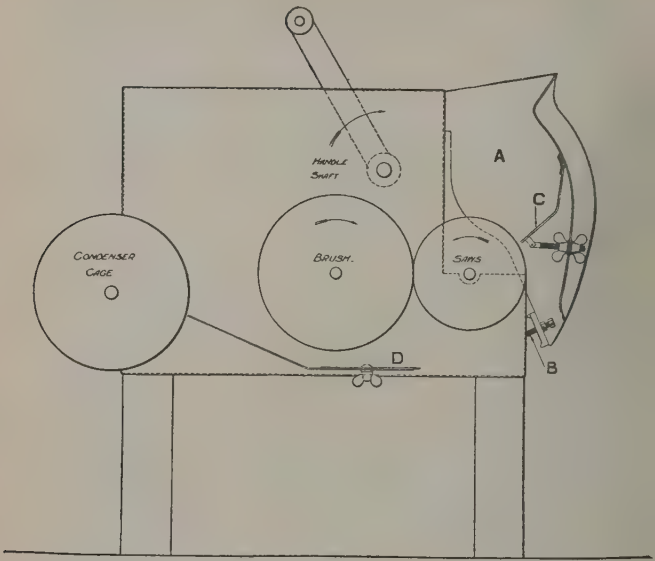
3. EGYPTIAN COTTON.—This type of cotton is a complex cultivated race of mixed origin in which *Gossypium vitifolium* and *G. barbadense*, both of which are New World cottons, play a large part. The former is largely a matter of conjecture, since it is based on a description by Alpino written in the sixteenth century.



COTTON: FIBRES OF PRINCIPAL COMMERCIAL TYPES

From top to bottom, Sea Island, Egyptian, Upland long-staple, Upland short-staple and Asiatic.

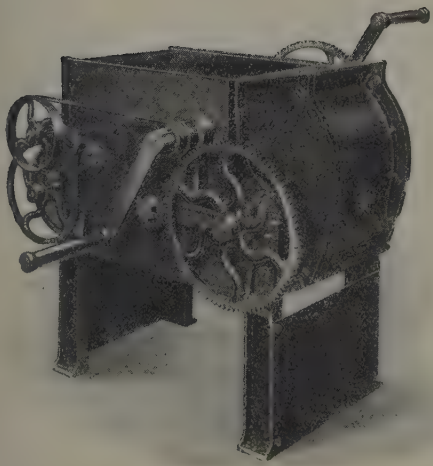
[*From "Southern Field Crops," by J. F. Duggar.*



HAND SAW GIN.

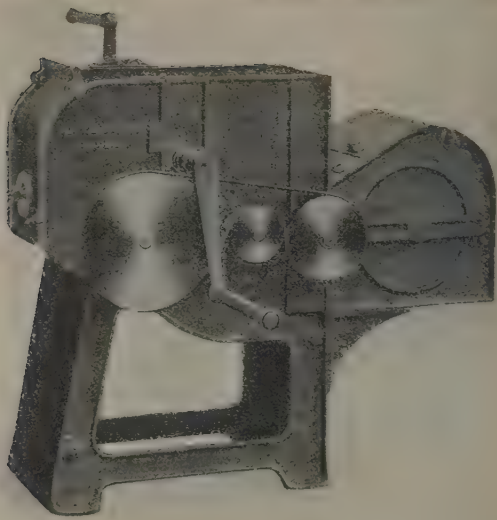
When the machine is erected the gratefall or roll box *A* is supported by the screws *B* on the framing. To gin fast lower the gratefall by turning down the screws, to gin slowly raise the gratefall. When the gratefall is moved the seed plate *C* will require adjustment in order to preserve the right distance between the plate and the saws for the escape of the seed. When the seeds are not cleaned sufficiently, move the plate *C* nearer the saws, when they are cleaned too closely move it away from the saws. If cotton drops under the brush move the mote plate *D* forward, if motes and dirt are not dropped move it backward. The machine should be well cleaned daily and the brush kept free from cotton and dirt. If the gin is running too fast and the seed is cleaned too closely the cotton is likely to be injured. It is important that the saws should run exactly in the centre of the spaces between the grate bars. The output depends largely on the class of cotton to be dealt with and the energy of the operator, but should be from 12 to 20 lbs. of ginned cotton per hour. The machine should be driven at a speed of 70 to 80 revolutions per minute. It can be driven by power, requiring about 1 h.p., on the adjustment of a pulley 6 ins. diam., 2½ ins. wide.

[*By courtesy of Messrs. Asa Lees & Co., Ltd.*



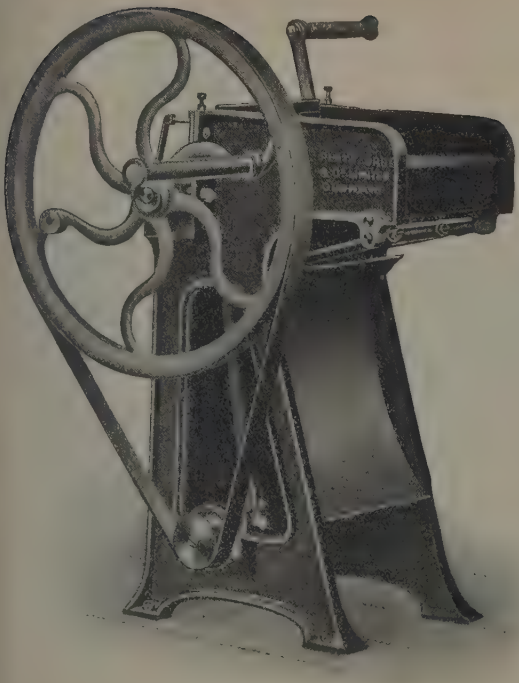
HAND SAW GIN.

16 saws with steel sides and ball bearings, described in detail with diagram on p. 510*b*.



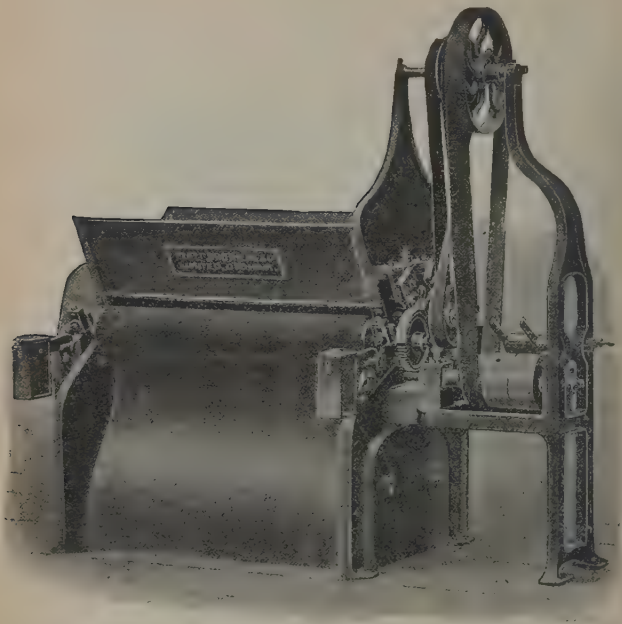
HAND SAW GIN.

16 saws, 8 ins. diam., with condenser, suitable for ginning American and other similar varieties of cotton. Two persons are required to work the machine, one to turn with both hands at the crank-handle, the other to turn with one hand and supply the roll-box with the other, the production of clean cotton being about 22 to 24 lbs. per hour. Before starting, the roll-box must be filled with seed cotton sufficient to form a roll, and as this is being ginned, a further supply is brought forward from the hopper. Speed of handle shaft 40 revolutions per minute; saw shaft 204 revolutions per minute. May also be adjusted to work by power with corresponding increase in production.



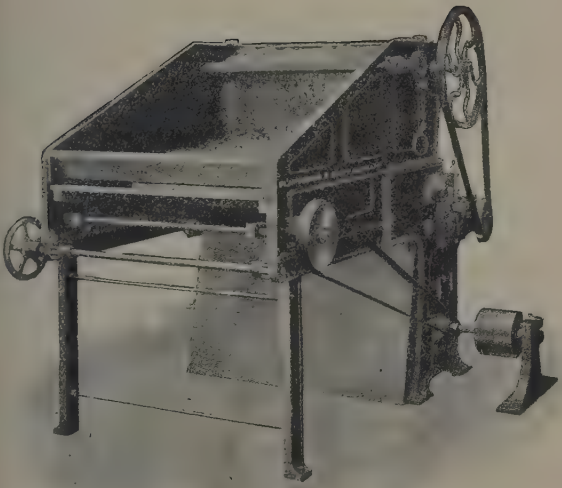
HAND-POWER MACARTHY COTTON GIN.

Suitable for ginning any kind of cotton without injury to the staple. Two persons are required to attend the machine, one to turn with both hands at the fly-wheel, and one to turn the crank-handle with one hand and feed with the other; the production being about 4 to 6 lbs. of clean cotton per hour according to class. Speed of handle shaft about 40 revolutions per minute. The machine may be worked by engine power by substituting a 16-in. pulley for the crank-handle.



DOUBLE ROLLER COTTON GIN, WITH OSCILLATING LEVER.

This machine is well adapted for separating cotton from the seed, more especially such as have the husk or shell covered with short fibre known as "fuzz" (or woolly seeded); recommended also for ginning short staple cottons and may be regulated for treating staples of various lengths, as required, the output of lint varying in general from about 50 to 80 lbs. per hour. It is self-feeding, as the cotton, on being thrown into the hopper, passes through without any further attention. The power required (exclusive of that for shafting, etc.) is about 3 h.p. and the speed is about 750 revolutions per minute.



SINGLE ACTION MACARTHY COTTON GIN.

40 ins., with 5 bearings; crank-shaft 1¼ ins. diam. Size of driving pulleys 6½ ins. by 3 ins. Power required—exclusive of that for shafting—about 3 h.p. Speed 700 to 900 revolutions per minute. The machine is shown fitted with Platt's Patent (Drawback) Feeder, which reduces the labour of feeding the cotton to a minimum, so that under certain conditions one attendant only is needed for 8 similar machines and the production of ginned cotton is thereby considerably increased.

The crop has, however, only been cultivated on an extensive scale since the beginning of last century, and it was due to Mohammed Ali, the founder of the Khedivate, together with a Franco-Swiss engineer named Jumel, that seed was multiplied of the tree cotton which gave rise to the brown linted cottons of the "Ashmouni" type, as well as for the interest in cotton in general which led to the introduction of the Sea Island stocks from which the more recent types of White Egyptian cotton—such as "Sakellarides"—owe their superior colour.

Brown linted cottons of "Ashmouni" type.

Egyptian cotton is essentially an irrigated crop, and though it has been tried in many other parts of the tropics and sub-tropics, the only places where it has survived and succeeded have been in dry countries where irrigation had to be practised, notably in the Anglo-Egyptian Sudan and in Arizona. Even though irrigation has been available, trials with this cotton both in Iraq and in Sind, India, have not proved successful, and the plant has rapidly degenerated. In Arizona it is not the true Egyptian which has been successful, but the progeny of two mutations, which have been named "Pima" and "Yuma," both of which are white-flowering cottons, as contrasted with the yellow flower with the red splash at the base of the petal of the true Egyptian.

Egyptian cotton an irrigated crop.

"Pima" and "Yuma" cottons.

The tendency in recent years has been to develop more and more the white-linted types of cotton rather than the brown-linted type. The reason for this is that the former come to maturity much more quickly and are therefore not so liable to damage from the "pink bollworm"—a pest which was introduced into Egypt at about the beginning of the last quarter of last century.

Development of white cotton in preference to brown cotton.

The system of cultivation in Egypt has undergone a radical change within comparatively recent times. In former times, when there was not the controlled irrigation which now exists, the fields where cotton was grown were enclosed with embankments, and these were flooded directly

Cultivation in Egypt.

from the Nile, the silt which was deposited replenishing the fertility of the soil each year. With controlled irrigation and a perennial supply this natural fertiliser was largely lost and embankments surrounding the fields were no longer required, but water was led on to the land as required by the crop. This has led to a system of furrow irrigation, the crop being sown in rows along the side of the ridge. When hoeing, this ridge is made up so that finally the cotton plant is in the centre of the ridge. Spacing of rows for sowing is wider than for the American Upland cotton, since the plant is of a much more straggling habit and grows to a greater height. Inter-cultivation is given between the rows after a short interval following irrigation, in order to conserve the moisture in the soil.

Cotton sown on ridges and irrigated along the furrows.

Spacing wider than for American Upland.

GINNING.—The ginning of this crop is done entirely with roller gins, and hence very clean and careful picking is necessary.

Roller gins.

4. SEA ISLAND COTTON.—This belongs to the species *Gossypium barbadense*. For many years it was grown along the Atlantic seaboard in Georgia and Florida, but owing to the damage by the Mexican boll weevil, on account of the long season required to mature the crop, its cultivation has now been abandoned there. It is now grown almost exclusively in the British West Indies, more particularly on the islands of St. Vincent, Montserrat, St. Kitts and Nevis. Recently its cultivation has been taken up to a limited extent in Fiji.

Sea Island cotton in Georgia and Florida.

Sea Island cotton in West Indies and Fiji.

This variety of cotton requires a coast climate for it to succeed. In habit it closely resembles that of Egyptian cotton—"Sakellarides"—though the types produced by selection in the West Indies do not grow to the same height and are more compact. Its cultivation in the West Indies is carried out entirely by manual labour. In St. Kitts it is a subsidiary crop, grown as a rotation crop with sugar, but in Montserrat and St. Vincent it is the main money crop of these islands. The general practice is to sow the cotton on

An insular climate essential.

Production in W. Indies by manual labour.

A rotation crop with sugar-cane.

small ridges spaced some four to five feet apart, the ridges running parallel to the slope of the ground so as to check wash. The seed is dibbled in by hand, and when they have four to five leaves the plants are thinned out to about eighteen inches to two feet apart; subsequent inter-cultivation is done with the hand hoe.

Ginning machines (see pp. 510*b*-*g*).

Baling presses (see pp. 513-514, 516).

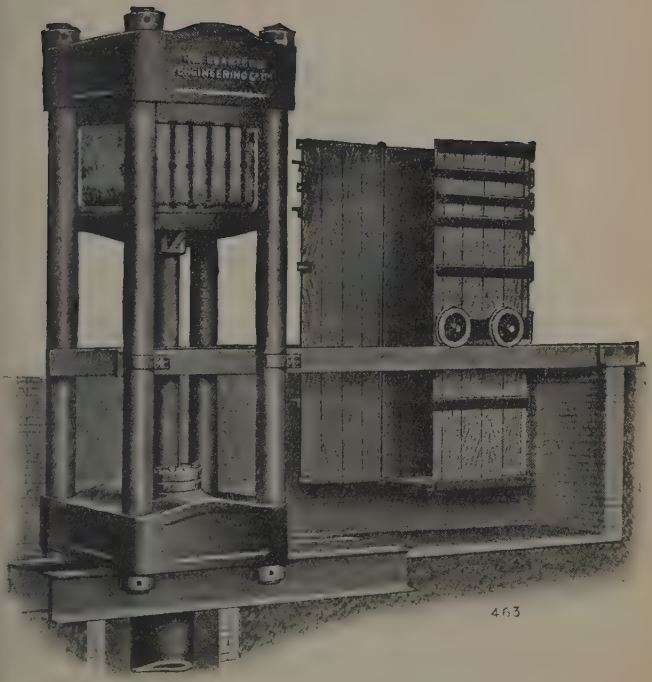
Market descriptions of cotton.

In all cases the cotton should be carefully picked, ginned, dried and baled. The standard bale is 400 lbs. in weight, but the Indian bale is 500 lbs. High density bales are pressed to 28 lbs. per cubic foot. In the principal markets of Europe and America the United States cotton is classified and graded on the new Universal Standard; "middling fair," "strict good middling," "good middling," "strict middling," "middling," "strict low middling," "low middling," "strict good ordinary" and "good ordinary." It would be exceptional for all these grades to come into the market at the same time; the first one may be rare and "strict good middling" to "middling," in practice, would probably cover the greater part of the American cotton crop, while the lower grades would indicate a bad season for the grower. The staple, which has an important bearing on the price, of the main commercial types, is shown on p. 510*a*.

KAPOK. *Eriodendron anfractuosum.*

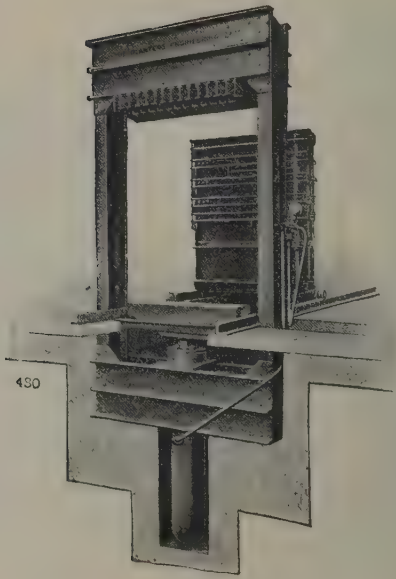
Propagation from seeds or cuttings.

A large tree 50 to 100 feet high, widely distributed in India, Ceylon, East Indies; cultivated on a commercial scale in the island of Java; cultivated in Togoland, East Africa and America. May be raised from seeds or cuttings, and in the plantation each tree requires a distance of about 18 feet. Plants raised from cuttings—strong, stout branches several feet in length—have been found to yield a quicker return than those from seed, and in general seem to be preferred. Raised in the nursery, seedlings may be transplanted after six to eighteen months or up to two years old. They should be topped when established to about a height of 2 feet, to induce branching. Growth is rapid and the



BALING PRESS ("DOMINION").

Total pressure about 300 tons (or more) for making 400 and 500 lb. cotton bales, working with one or two boxes. This press bales any of the fibres dealt with in the chapter, different baling boxes being used for different fibres.



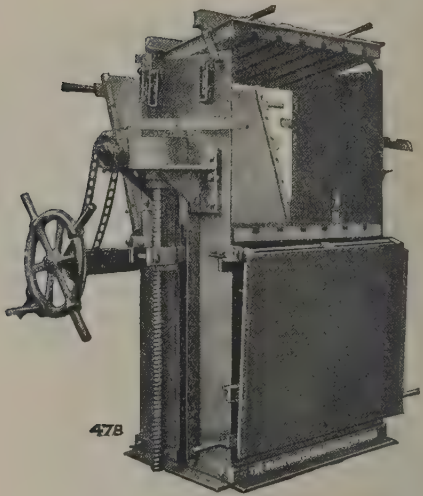
BALING PRESS ("FRAME").

Suitable for all classes of extracted fibre and "broom corn" (p. 541). Also for tobacco (p. 330), etc., or any product requiring medium pressure.

HYDRAULIC PRESSURE PUMP.

For supplying the water under high pressure to the baling press.

[*By courtesy of the Planters' Engineering Co., Ltd.*



BALING PRESS ("COLONY").

A screw press operated by hand, for making half bales of cotton, wads of sisal, kapok, or other products (tobacco, etc.) where light pressures only are required. The press can be made for belt drive, for use with power.

young trees begin to bear fruit when about four to six years old. When the trees grow too high they may again be lopped to a convenient height for collecting the bolls. The yield is variously estimated, but at the age of five years each tree may yield about 300 fruits, giving about 3 lbs. of kapok, while a fully developed tree may yield several thousand fruits, each yielding 4 to 5 grammes, or a total of from 40 to 50 lbs. of kapok. Young saplings of kapok trees are recommended to be grown as supports for the "pepper vine" (*Piper nigrum*)—see under "Spices," p. 302—and where this is convenient the combination under cultivation might prove very profitable. The pods should be gathered when they are just ready to burst, and careful picking, drying, ginning and baling are essential. Ginning is largely done by machinery, but sometimes by hand—by beating with sticks on a table with holes for the seed to drop through, or by the use of basket sieves. Hydraulic or steam-press packing is liable to damage the fibre by destroying its resiliency, and for the same reason the bales are made lighter than those of cotton—a bale of Java kapok weighs about 80 lbs., Ceylon 200 lbs., and Indian upwards of 400 lbs. The lighter bales usually fetch the best prices. The Dutch East Indies have always been the chief source of kapok, and at the present time the supplies are chiefly from trees grown in plantations largely in Java. Prices in 1913 were for Java 8*d.* to 8½*d.*, Ceylon 5½*d.*, and Indian 4*d.* to 6*d.* The prices at present (1928) are, for Java kapok 1*s.*, Ceylon 10½*d.*, and Indian 9*d.* per lb. The fibre is not suitable for textile purposes like that of cotton, due to shortness of staple and other mechanical defects which make it unsuitable for spinning, and to the low percentage of cellulose. Its chief value, due to its buoyancy in water, lies in its suitability for making life-saving apparatus—life-belts, life-buoys, &c. It is also used for stuffing pillows, mattresses, cushions, &c. Java kapok is usually specified for making life-saving apparatus, but both this and Indian kapok meet the requirements of the Board of Trade

Yield.

Bales lighter than those of cotton.

Market prices.

Uses.

for the purpose, although the latter is not always acceptable, having regard to the possibility of it coming in mixed with "akund fibre."

Akund. *Calotropis procera.*

A shrub or a small tree 3 to 12 feet high, found in tropical Africa and extending to India. Raised from seed and easily cultivated, though not much of this is known under cultivation, the supplies coming from wild plants. "Akund" is inferior to kapok, with which it is classed in commerce. It is only a few years since it began to come into the English market. It is collected in India and is also believed to come mixed with kapok. It is probable the silk floss from *Calotropis gigantea*, common in India, may also come into the markets under the name of "akund." The two plants may be taken together in treating of their uses. The Indian name of this species is "Madar." Akund fibre does not meet the requirements of the Board of Trade for life-saving appliances and its use is confined to stuffing cushions, mattresses, pillows, &c. The Bengal name is "akanda," and in Senegal it is called "fafetone." In 1915 the value was 2½*d.* to 3½*d.* per lb. In 1911 the Journal d'Agriculture Tropicale recorded that some 8,000 bales of "akund" or "fafton" fibre were imported into Europe annually.

Sources of akund fibre.

Uses.

Leaf fibres.

The "Leaf fibres" included below are Sisal Hemp, Mauritius Hemp, Sansevieria, and New Zealand Flax or Hemp.

Sisal Hemp. *Agave sisalana.*

A low-growing plant with a short root-stock and a rosette-like head of leaves—pale green, fleshy, 3 to 6 feet long 3 to 5 ins. wide in the middle, edges usually smooth with a terminal spine. Native of Central America and cultivated in the Bahamas, East Africa, Tanganyika, Kenya, Nyasaland, Natal, S. Africa, India, East and West Indies and Fiji. The plant is propagated by bulbils—which grow on

the flowering spike, when the plant matures and dies—or by suckers arising from the root-stock. Bulbils set out 8 or 9 ins. apart each way in nursery beds may be grown on until about 8 to 12 ins. or so high, or after six months' growth, when they may be planted out 8 or 9 feet apart in the field. Suckers may be put out at the same distance apart as soon as strong enough to remove from the parent plant. A limestone soil, well drained, and a dry, hot climate are essential. In Yucatan the soil in the fibre-producing districts is gravelly and stony, varying in colour—black, brown or red—with soft limestone sub-soil. The plants mature in from three to five years, when approximately 25 to 50 leaves may safely be taken from each plant in the course of a year. They are cut from below when of full length, but not less than 3 feet, and cutting may go on until the plants pole or flower, a period which may vary from six to ten years to more than twenty, according to the climate. In East Africa the short period of two to three years for cutting is recorded, or putting the life of the plant there at 6½ years, reaching maturity in the third year and cutting for nearly four years before poling. Under favourable conditions the leaves yield 3½ per cent. of clean, dry fibre, or about 1½ to 2 tons of dry fibre should be obtained from the 85,000 to 120,000 leaves mentioned below. The leaves are tied in bundles and conveyed to the mill, which should be conveniently situated near a good supply of water. On most plantations where the plant is grown commercially, machinery is used, and it is only on a scale sufficiently large to require machines for cleaning that the cultivation would be likely to pay. The cleaned fibre is hung on lines to dry and bleach, and afterwards baled for shipment. There are several machines on the market for extracting the fibre. A machine of 48 h.p., called the "Molla," used in Yucatan and formerly in East Africa, can treat 85,000 to 120,000 leaves in ten hours, and requires the produce of at least 600,000 plants, covering 300 acres, to keep it going profitably.

Propagation by bulbils or suckers.

Soil.

Cutting the leaves.

Yield.

Extracting machinery.

ROBEY DECORTICATOR ("SUPERDECOR") FOR TREATING SISAL LEAVES.

A, Link chains on which the leaves are fed lengthwise. B, Point at which the leaves (marked C) are drawn between the feed-drum, D, and the conveyor chain, E, underneath. F, Section of feed-drum. G, Blower to control the movement of the fibre towards the top of the second feed-drum, DI, so that the uncleaned portion of the leaf is cleaned, the completely cleaned fibre being finally delivered at the point H, where a man stands to clear it. This machine also treats Mauritius hemp leaves successfully. Power required, 80 b.h.p. Capacity about 13,000 leaves per hour, giving a yield of 2½ to 4½ tons of fibre per day of 10 hours according to length and condition of leaves.

SISAL HEMP PLANTATION.

Many of the plants poling—and cut leaves being transported to the decorticator.

[*By courtesy of Messrs. Robey & Co., Ltd, Lincoln.*

WASHING SISAL HEMP.

DRYING SISAL HEMP.

[By courtesy of Messrs. Robey & Co., Ltd., Lincoln.

SISAL HEMP PLANTATION, JAMAICA.

[From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.

A smaller machine (makers, Finnigan, Zebriske & Co., Paterson, N.J , U.S.A.) of 12–14 h.p , takes 4,000 leaves per hour—a man feeding the leaves and a girl taking off the clean fibre ; this is used in Jamaica. An estate of 1,250 acres in the Bahamas has two machines—one Todd and one Villamor in use (output about 79 tons) for preparation of the fibre. The above particulars as to machinery are necessarily very brief and merely give some indication as to requirements ; for fuller information reference should be made to papers in the Kew Bulletin, Bulletin of the Imperial Institute, &c., quoted below, on the subject. It is also advisable before purchasing machinery to consult the makers, who are always willing to give reliable details of any particular machine that has been proved successful in various parts of the world. A modern machine for sisal is shown on page 520.

Uses. Sisal is used largely for rope and cordage manufacture ; binder twine is now made with this fibre, an important competitor for this purpose being New Zealand flax. Sisal is one of the most important of the "hard fibres," furnishing half the total production of this class of fibre, Mexican[1] sisal affording the greater share. "Prime sisal" was quoted in Dec. 1926 at £42 and in July 1928 at £34 per ton.

Mauritius Hemp. *Furcræa gigantea.*

A low-growing plant sometimes developing a stem 2 to 4 feet in height, with a rosette-like head of upwards of fifty leaves, 4 to 7 feet long, 4 to 6 ins. across the middle, thick, fleshy, with a short terminal spine, otherwise unarmed. Native of tropical America. Cultivated on a commercial scale in Mauritius, St. Helena, Natal, in Colombia, &c. In general the propagation, cultivation and preparation may be regarded the same as for sisal. Plants are put out at 4 by 4 feet or 5 by 5 feet according to soil and climate. These distances are recommended in Natal, but it is probable, considering the length of leaf when fully developed, that the distance apart in the field may be

Propagation, &c., as for sisal.

[1] The chief Yucatan plant is called "Henequen" (*Agave fourcroydes*), said to furnish 90 per cent. of the sisal of commerce.

better equal to that given for sisal in a tropical climate. The leaves may be cut about four years after the plants are laid out, a second cutting ten months later, a third fifteen and a fourth eighteen months afterwards, and so on every eighteen months until the plants pole, or flower, and die. Bulbils for reproduction are developed as in sisal. An acre of plants should give about 60,000 leaves, yielding a ton of fibre. The local methods of extraction have not been superseded by machinery, especially in Mauritius where a small hand apparatus called a "gratte" is in use. Experiments with the Robey decorticator as used for treating sisal have shown this to be suitable, after proper adjustment, for decorticating the leaves of *Furcræa*.

The market value of this hemp is about equal to that of sisal and similar cordage fibres. In Colombia, where the plant is called "fique," the fibre is used for soles of alpargatas (shoes), for making sacks for the transport of coffee, charcoal, maize and produce generally, pack-saddles, ropes, cord and matting. The plant is called "aloe" in Mauritius and Natal, where it has become more or less naturalised.

Bowstring Hemp. *Sansevieria*, spp.

"Bowstring hemp," various species of *Sansevieria*.

The genus *Sansevieria* is an extensive one, including several species that produce fibre known under the name of "bowstring hemp." This name is stated to have been proposed by Dr. Roxburgh in India, because the natives of the Circars (India) make their best bowstrings of *Sansevieria* fibres. The species are all perennial plants with leaves which may be flat or strap-shaped, cylindrical or semi-cylindrical, &c., 1 in. thick from side to side, 1¼ to 1¾ ins. from front to back, arising from a creeping root-stock or with a short stem hidden by the leaves, crowded near the base. Those with leaves long enough to yield fibre are comparatively limited; they include *S. Ehrenbergii*, with five to nine leaves arising from a short stem (9 ins.)

2½ to 6 feet long, more or less rounded, about an inch or more through, channelled and grooved. Native of Somaliland, Nubia, &c., the fibre being used for making ropes. *S. cylindrica*, Bojer, with a stout, creeping root-stock, leaves 2½ to 5 feet long, cylindrical or slightly compressed, about 1 inch through; native of Angola, where the fibre is called "ife," and used for making ropes. *S. trifasciata*, Prain, with a creeping root-stock, leaves 1 to 4 feet long, flat, except at the base, 1 to 2¾ ins. broad, transversely banded with varying shades of green; native of West Tropical Africa; yields a fibre suitable for cordage. A variety *Laurentii*, N.E. Br., native of the Belgian Congo, has leaves striped with golden yellow near the edges, otherwise exactly as in the type. *S. metallica*, Ger. & Labr., with a creeping root-stock, leaves coriaceous, smooth, strap-shaped 1½ to 5 feet long, 2 to 5 ins. broad, dark green, more or less banded or blotched with pale green; native of tropical Africa, and believed to be identical with the plant widely cultivated as *Sansevieria guineensis;* yields a fibre suitable for cordage. *S. Kirkii*, Baker, with creeping root-stock, leaves 2½ to 6 feet or up to 9 feet long, strap-shaped, 2½ to 3½ ins. broad, native of Tanganyika, Zanzibar, &c. Division of root-stocks is best method of propagation, but plants may be raised from seed or from leaves or pieces of leaves put in as cuttings; planted out about 3 feet by 3 feet, the plants should soon cover the ground: otherwise the cultural and climatic requirements are approximately the same as for sisal or Mauritius hemp, and also as regards the extraction of the fibre. There is little or no satisfactory information as to yield, as the *Sansevierias* have not the importance of either sisal or Mauritius hemp under cultivation; but under favourable conditions a fair estimate would be 1½ tons of dry fibre per acre.

Propagation.

New Zealand Flax. *Phormium tenax.*

A liliaceous plant, with leaves upwards of 8 feet long, 3 to 4 ins. wide, arising from the base of the plant near the

ground; native of New Zealand. Cultivated on a commercial scale in St. Helena. May be raised from seed, but the best fibre-producing varieties cannot be relied on to come true, and the best method of reproduction is by division of the roots or root-stocks. In its native country it is found in swampy lands and near the edges of streams and lakes, but grows freely in almost any soil, favouring for its best development rich, moist, though well-drained soil. Although in its native country it is within the temperate region, the climate it thrives in best seems to be of a sub-tropical character, and in St. Helena, a distinctly tropical country, the plant thrives to perfection. The production in New Zealand is chiefly from wild or semi-wild plants, but there seems to be little doubt that cultivation is on the increase, and by careful selection of the matured leaves a more desirable production will be ensured. The preparation on a commercial scale has always been more or less a difficulty. The Maori selects only leaves that are "ripe," and the hand method of preparation he practises, though tedious, has not been superseded for quality and capability of being woven into cloth equal to linen. Manufacturing processes—chiefly chemical—have been recommended, with the result that a fibre can be produced which runs the native-prepared article very closely. The machinery in use does not appear to be perfect, but it produces an article suitable for meeting one of the most important uses—the manufacture of binder twine and cordage. Upwards of 20,000 tons are imported yearly into England alone, and the value per ton is about £45.

Propagation—best method by division of roots.

Climate.

Preparation in New Zealand.

Extraction by chemical processes and machinery.

PINE-APPLE. *Ananas sativus.*

A fibrous-rooted plant with a rosette-like head of leaves arising from the ground, thirty to fifty on each plant, 3 to 5 feet long, about 2 ins. wide at the middle, with either prickly or smooth edges according to variety. Native of tropical America; cultivated in many tropical countries, in

Fibre of local value.

Asia, Africa, America and Australia, and in sub-tropical countries, Natal, Florida, California, more commonly, for the fruit. As a fibre-plant it is grown in the Philippines, Formosa, Hainan and Java, where the fibre is of local value only, or as in Formosa, exported only to China and neighbouring countries. The "pina" cloth of the Philippines and the "grass cloth" of Formosa are made of this fibre. There is no trade in pine-apple fibre in this country. In the countries of production the preparation of the fibre is by a tedious hand process. In Hainan, for instance, a dozen leaves or so are gathered the first or second year from each plant; they are scraped on both sides to remove the green tissue. The fibres are then alternately macerated in cold water for six hours and dried in the sun several times, extending over three days. In the Philippines each layer of fibre is removed as it is exposed by scraping, and 50 to 60 lbs. of fibre is obtained per ton of green leaves. Trials have been made in Florida, Malacca, S. Rhodesia, Gold Coast, N. Nigeria, &c., and although some good samples—some up to 6 feet in length—have been obtained, it does not seem to have been possible to produce the fibre on a commercial scale. See under "Fruits" for particulars of cultivation, but it is not recommended to grow plants for fruit and fibre at the same time.

Fibre prepared by hand.

Various Bromeliaceous fibres. "Silk Grass."

"Caroa."

Other Bromeliaceous fibres are "Pinguin" (*Bromelia Pinguin*, L.); "Silk Grass" (*Karatas Plumieri*), common in Honduras and Central America, with leaves 8 to 10 feet long, valued locally for making hammocks, &c.; "Caroa" (*Neoglaziovia variegata*), with leaves up to 6 or 8 feet long, native of Brazil, and "Pita" fibre (*Bromelia Magdalenæ*), with leaves 6 to 8 feet long, native of Colombia and other parts of South America, in all of which the cultivation and treatment for fibre would be much the same as for pine-apple. The last mentioned has only recently come under notice. "Pita" fibre or "silk grass" (*Bromelia Magdalenæ*, C. H. W.), is a pine-apple-

Colombia pita fibre.

like plant with strap-shaped leaves 6 to 8 feet long, native of Colombia and other parts of South America. Considerable interest has been taken in this plant recently and its cultivation has been under experiment in various tropical countries. In its native habitat it is reported to thickly cover vast areas usually under the shade of forest trees. The fibre is strong and durable, used locally for fishing-nets and various articles. Samples have been valued in London at £40 per ton.

Stem or Bast fibres.

The principal Stem or Bast fibres are "Jute," "Sunn Hemp," "Bimlipatam Jute" (*Hibiscus*), "Roselle Hemp" (*Hibiscus*), and "China Grass" or "Ramie."

JUTE. *Corchorus capsularis*[1]

An annual plant with stems growing 8 to 10 feet, sometimes 12 feet, high; leaves 2 to 4 ins. long, about 1 in. broad, petiole 1½ ins. Capsule small, subglobose, five-valved. Native country not known, but cultivated chiefly in Bengal, whence our chief commercial supplies of the fibre come. There are several trade descriptions in India, including "Uttariya," with long and strong fibre of the finest grade; "Deswal," a second-grade quality; "Daisee," generally used in the gunny trade, and "Deora" or "Dourah," used in rope manufacture.

Trade descriptions of jute.

Seed may be sown broadcast at the rate of from 8 to 15 lbs. per acre. The field should be thoroughly prepared before sowing by ploughing and tilling. A rich, loamy soil or deep alluvium, moist but well drained, is essential to produce good crops. Where manure is necessary, an application of from 4 to 5 tons of farmyard manure or cow-dung is a valuable dressing for ploughing in before sowing. An application of bone-meal, castor-cake or similar manure not readily washed out of the soil, may also be found beneficial if natural manures are not available.

Propagation.

Manuring.

Germination takes place in a few days, and in about a fortnight the plants will be developing their second leaves.

[1] The Bengal Agric. Dept. has done much in recent years to improve the jute plants by seed selection—including *C. olitorius*, which thrives on higher land than *C. capsularis*.

The plants are thinned out to a distance of from four to six inches, or kept sufficiently close to prevent branching. The crop may take from three to four months to come to maturity, and harvesting should be commenced when the plants are partly in flower and partly in fruit.

The cut stems are stooked (stood on end like corn-sheaves) in bundles to dry the leaves.

The stems, which may grow from ten to twelve feet high, are cut near the ground, tied into bundles, stooked for a few days until the leaves dry, and then submerged in a tank or pool of clear water to ret or steep until the fibre is found to separate easily from the stem. The retting may occupy from ten to twenty-five days, according to the weather and to the condition of the plant. It is important that the stems be removed at the right time, as the fibre soon becomes impoverished and discoloured if allowed to remain in the water too long. The fibre is stripped from the stems, washed, for preference in running water, until all the bark is removed, and then dried in the sun. When thoroughly dry the fibre is graded and baled for export. The rough ends from near the base ("jute butts"), approximately six to eight inches long, are cut off and baled separately. The baling is usually done by machinery (see illustration, p. 513), and a commercial bale weighs 400 lbs.

Baling press.

A good yield is estimated at from 2,400 to 2,500 lbs. of fibre per acre, though it may vary between 1,000 and 3,000 lbs. The annual crop sometimes reaches 2,000,000 tons, and the new Indian jute crop begins to arrive about August on the London market, where the prices ruling at the present time (June—Aug. 1928) average £36 per ton for "first marks," though in the course of a year the prices have been known to fluctuate between £28 and £60 per ton. The total annual imports into the United Kingdom are approximately 150,000 tons; the acreage under jute in India exceeds 3,000,000.

Experiments in the cultivation of jute are being made in other tropical countries—in Trinidad, West Africa, &c.—but the monopoly is held, as it always has been, by Bengal.

Sunn Hemp. *Crotalaria juncea.*

A shrubby plant 6 to 10 feet high, found wild in Ceylon, Burma, and distributed to Malaya and Australia. Cultivated as a fibre plant in India. Raised from seed, which may be sown broadcast on land well prepared by ploughing and harrowing. A moderately rich soil, light and well drained, is suitable. About 50 to 80 lbs. will sow an acre. Germination is rapid, and the seedlings should be thinned out to about 3 or 4 ins. apart, being kept as close as is consistent with proper development to prevent branching and to encourage the growth of tall, straight stems, 6 to 10 feet high. When once established in the field, little or no care is required, and the plants come to maturity in three to four months. It is recommended to cut when in flower or with the pods set if the fibre is for fine purposes, or when the seed is ripe, for stronger and coarser purposes, though opinions may differ in this respect. In some parts of India the branching tops are cut off before reaping and used for fodder. Harvesting, retting and preparation is much the same as for jute (*Corchorus capsularis*). A good yield of fibre would average about 700 lbs. The fibre is imported under the name of "East India hemp" or "sunn hemp," chiefly if not entirely from India; value at the present time[1] £26 to £28 per ton. It is strong and durable and used for making cables, ropes, twine, sacking, &c., or similar to that of the well-known European hemp (*Cannabis sativa*), for which, when properly retted and cleaned, it makes a good substitute.

Propagation.

Harvesting, retting and preparation same as for jute.

Deccan Hemp or Bimlipatam Jute. *Hibiscus cannabinus.*

A perennial plant grown as an annual; stems the height of jute or sunn hemp; found in tropical Asia and Africa. Propagated by seed, sown broadcast fairly thickly, the plants being thinned out to a few inches apart when large enough to handle. In general the treatment under cultivation

[1] August 1928.

Treatment in general as for jute.

is similar to that for jute. A rich, open soil is the most suitable, but it has been found to do well in dry lands, in red loams and black soil. For fibre production the plant requires three or four months to come to maturity; the stems are usually cut at the flowering stage, but they are said to yield a stronger fibre when mature. In India the yield has been given (Watt) as nearly 3 tons per acre—allowing 640,000 stems, of which each hundred produce one pound of fibre. Another estimate is nearly 1½ tons per acre. For quality this fibre is understood to be as good as and possibly superior to, average jute, for which it forms an efficient substitute in the manufacture of cordage, sacking or any of the coarser textiles. It comes into commerce under the name of "Bimlipatam jute," chiefly from the Madras Presidency, though it is cultivated in other parts of India and Africa. In Nigeria the plant is grown for fibre under the name of "rama" or "ramma," and in French West Africa as "da."

Yield.

Bimlipatam jute.

ROSELLE HEMP. *Hibiscus Sabdariffa.*

Stems 6 to 7 feet high; cultivated in tropical Africa and most tropical countries, interest being taken in the variety *altissima* as a fibre plant in the Federated Malay States, Philippines, &c. Yields a strong silky fibre resembling jute, suitable for the same purposes; treatment in every way similar to this and to *H. cannabinus*, thus adding one more to the several known substitutes for Bengal jute.

Other fibre plants belonging to the family *Malvaceæ* that may be worthy of mention, though at present only of local value, are:

Hibiscus lunariifolius, Willd., a native of India and widely distributed in Africa; yields a good fibre commercially described as jute. Treatment under cultivation would be the same as for the foregoing. *Hibiscus tiliaceus*, Linn., known as the "lime tree-leaved hibiscus"; widely distributed in the tropics; yields a useful fibre suitable for

making cordage, mats, &c.; suggested as a substitute for jute, but a special feature is said to be its durability under water. This develops into a tree, but, raised from seed and treated as an annual, it may be an advantage to grow it like the above-mentioned, from which it would differ in that it grows freely in low-lying, swampy ground, being found near the coast-line of many tropical and sub-tropical countries.

Urena lobata, Linn., the "carrapicho" plant of Brazil, and widely distributed in tropical and sub-tropical regions of both hemispheres. The stems yield a fibre of good quality used locally for making ropes, bags, twine, &c. This plant is believed to be the source of "aramina" fibre, used for making coffee bags in Brazil, and in every way a good substitute for jute; the treatment as to cultivation, preparation, &c. would be much the same. Carrapicho.

Sida rhombiifolia, Linn., a perennial plant known as "sida hemp" and "Queensland hemp"; widely distributed in the tropics. Although perennial it may be grown as an annual, treated like jute, the fibre being regarded as a good substitute but superior to it in quality. Sida hemp.

CHINA GRASS, RHEA. *Bœhmeria nivea*. GREEN-LEAVED CHINA GRASS, RAMIE. *B. nivea* var. *tenacissima*.

"China grass" or "rhea" (*nivea*) is a herbaceous perennial with stems 3 to 6 feet high. Leaves broadly ovate, 3 to 6 ins. across, green above, downy white below. Flowers nettle-like. Native of China, cultivated in temperate and the cooler parts of some tropical countries, including Japan, Formosa, Philippine Islands, Burma, India, Australia, Europe and America. "Green-leaved China grass" or "ramie" (var. *tenacissima*) is similar in general botanical characters to the type, excepting the leaves, in which the white-felted appearance of the underside is absent. It is a native of Malaya and cultivated in many tropical countries. For all practical purposes the two plants, although distinct botanically and requiring different climates, are approxi- Ramie and rhea the same for all practical purposes.

mately the same ; may be propagated from seed, layering cuttings and division of the roots, the last mentioned bein the best method. Rich, well-drained soil is essential, wit continual application of manure during the whole life of th plantation, which under favourable conditions may last man years, giving two or three crops a year. If intensive cultiva tion is not possible, in order to keep the soil vigorous it i advisable to replant new areas as the soil becomes exhauste Experiments have been made in nearly every British Colon and in certain foreign countries for many years—half century and upwards—but comparatively few of th experiments have developed into production on a commerci scale. The main difficulties that appear from the outset t have been met with are comparatively high cost of cultivatio —the yield of useful fibre from the stalks being lower tha that of other textile fibres—degumming, inflammabilit and low market prices. Various methods have been pu forward from time to time for cleaning the fibre, includin mechanical and chemical—by the aid of steam, bacteri petroleum-soap, &c.—details of which it would not be profit able to enter into. In the absence of machinery or som fairly inexpensive method of preparation, it does not seer easy to compete successfully with the Chinese product, th more so when all the home requirements of the trade migh be met from China. As a rule, those who claim to hav invented a successful process of preparation are not usuall open to disclose it. Some experiments recently made at th Royal Naval Cordite Factory, Dorset, on a fermentatio process, using stems grown at Kew, go to show, accordin to the favourable report of a leading authority on rami utilisation on the samples obtained, that the method come nearer to success than hitherto in its commercial possibilities In China, whence our chief commercial supplies of fibr come, the preparation is all done by hand—the bark i stripped off into ribbons, which are retted for two hours i water, then scraped and dried. There are three qualities determined by the length of fibre ; sorted into first quality

Good cultivation required.

Processes of extraction under experiment.

30 to 40 ins.; second quality, 20 to 30 ins., and third quality less than 20 ins., tied into bundles for export with a rope of ramie itself as a binder. Baling with the aid of hydraulic presses is reported to be done at the ports of shipment. The fibre is used for the manufacture of "grass cloth" in China, and for various purposes similar to those of linen and cotton, and incandescent gas mantles in Europe. Trade quotations are for "rhea," "decorticated ribbons" and "China grass"—unbleached or more or less cleaned fibre. In 1913 (quoted here because pre-war) China grass realised £40 to £50 a ton, and in 1919 the value was £95 to £120 per ton, but the records available for rhea or ramie ribbons for approximately twenty years, beginning with 1904, indicate how very rarely this form comes into the market, the reports almost invariably being "No Stock" or "No Business." Fuller information will be found in the general and special works mentioned below.

Trade.

Rhea or ramie ribbons.

The following fibres are difficult to classify :—

1. "Manila hemp" is obtained from the stem of a *Musa*, but it cannot be included as a bast fibre with the above as this element does not occur in the monocotyledons. 2. "Coir fibre" is obtained from the fruit husk of the coconut palm ; it is sometimes classed with the brush or mat fibres ("piassava," "raphia" or "Lagos bass," &c), which mostly do not lend themselves to cultivation ; there is no other fibre in commerce obtained from the fruit husk. 3. "Broom corn" is part of an inflorescence, and though this might also be put in with the brush fibres, there is no other fibre in commerce produced in the same way.

Manila Hemp. *Musa textilis.*

A perennial plant, stem 20 feet or more high, in general appearance like the banana, but the fruit is not edible. Native of the Philippine Islands, where it is also cultivated. Under experimental cultivation in various tropical countries,

including Jamaica, Trinidad, India, Borneo, East and West
Propagation. Africa, &c. May be propagated by seed, but usually plantations in the Philippines are increased by means of suckers, planted out when about 3 feet high at distances of from 8 to 9 feet apart. A rich, open soil, thoroughly drained, and heavy rainfall are essential. The first crop will be ready two years after the planting, and a full crop in the fourth year, when the yield will be 400 to 700 lbs. of dry fibre per acre. The plantation continues for from fifteen to
Harvesting. twenty years. The stems are cut for fibre just before flowering. After removal of the leaves each stem is divided into strips or ribbons about 3 inches wide- usually each layer or leaf-sheath is divided into three strips. The outer layers contain a coarser and stronger fibre than the inner, while fibre from near the middle is of a fine silky texture and capable of being utilised for purposes of spinning or weaving
Extraction of fibre. into articles of dress or ornament. The method of preparing the fibre is very simple but effective. Each strip in a fresh, succulent condition is taken up by hand and drawn deftly between a blunt knife and a hard smooth board, which are attached to a light portable frame. This process, repeated several times if necessary, removes all the watery particles and pulp, leaving in the hands of the operator a beautifully white and lustrous fibre. One man can clean about 20 lbs. of hemp per day. This is thoroughly dried in the sun and afterwards packed in bales of about 275 lbs. each for shipment. Special care is taken in grading the several qualities which may vary according to variety, cultural conditions, &c. The hand method with the simple apparatus described above does not seem to have been improved upon. Machines have been tried with success, but where labour is abundant and cheap they are not considered advantageous. Some 500,000
Market prices. bales, or upwards of 20,000 tons, come into London from Manila; the price in 1913 was £24 to £90 per ton: in Jan. 1920, £57 to £100, in Oct. 1926, £40 to £45, with Prime Sisal at £43, and in July 1928, £37 per ton. Very

satisfactory samples have been produced under experimental cultivation in Trinidad, foot of the Nilgiris—India, British North Borneo, Solomon Islands, the Belgian Congo, &c., indicating the possibilities of development on a plantation scale in the tropics, where suitable conditions are available. Manila hemp is one of the most important sources of the white fibres, used for ropes and cordage and binder-twine chiefly, but twine, fine fabrics and paper are also made from it, worn-out ropes being suitable for the latter purpose. The best qualities of stout packing papers and other similar papers in the United States are made from old Manila ropes. Uses.

Coir. *Cocos nucifera.*

Coir fibre is obtained by retting the husks of the coconut palm in tanks of water for 6 to 9 months; they are then split into four or five pieces and the fibres are combed, washed and dried in the sun. When dry the fibres may be separated by further combing and graded into equal lengths, the long, straight fibres for brush-making and the combings for mat-making. The grades are packed separately in bales weighing from 1 to 2 cwt. The method of preparation in Trinidad, as described by the Director of Agriculture, is that "the husks are first battened down in concrete tanks "and soaked in water for about five days, after which they "are passed through a crusher composed of a pair of cogged "rollers pressed together by heavy springs. The cleaning "mill consists of a rotating drum about 30 ins. in "diameter, fitted on the periphery with steel spikes. In "front of this drum there is a pair of small feed rollers "through which the husk is fed and held against rotating "teeth. The husk is passed through these rollers as far "as possible without letting go of it. It is then drawn back "and turned end for end. After that it is turned over and "the operation is repeated. The long-staple fibre, generally "known as the brush fibre, remains in the operator's hands "and the short-staple fibre, known as mattress fibre, is Preparation of the fibre.[1]

[1] Commerce Report, Washington, Oct. 24th, 1919.

"drawn into the machine. So far as the long-staple fibr
"is concerned it is now finished except for drying. Th
"mattress fibre, containing all the refuse, is taken fro
"under the cleaning mills and put into the willowin
"machine, which is an inclined revolving drum covere
"with ½-in. wire mesh and containing revolving beate
"drums mounted on a shaft which rotates in the opposit
"direction to the drum. The fibre is then spread out i
"the sun to dry, which in fair weather can be done in a day
"Finally, it is hydraulically pressed into bales, measuring 2

Yield. "by 20 by 40 ins., and weighing about 180 pounds." Th husk from 1,000 nuts, weighing 1,700 lbs., gives approx mately 400 lbs. of fibre of all grades. The residuary dus

Trade sources. when dry is about half a ton. The chief commercial source of the fibre are Ceylon and Cochin; the former valued i 1920 at £27 to £33 per ton, and the latter £25 to £5 per ton. In 1924 Ceylon coir was valued at about £11 an Indian £19 a ton. For cultivation see Coco-nut Palm, p. 23

FLORENCE WHISK OR BROOM CORN. *Sorghum vulgar* (*bicolor*) var. *technicus*.

Description. An annual plant 10 to 15 feet high, usually called th standard variety, and 3 to 6 feet high a dwarf variety. Dry pithy, yellow when ripe, ¼ to ¾ in. thick, and from 4 to ins. from the top of the short rachis, from which th slender brush-fibres or seed-heads (fifty or so) arise com pactly, to a varying length of 1 to 2 feet, nodding slightl

Seeds like those of Guinea corn. in the growing plant. Seeds similar to those of the Guine corn, varying in colour from reddish-brown, yellowish reddish or blackish. Cultivated in various tropical and sub tropical countries, including United States, West Indies Nyasaland, Queensland, New South Wales, Italy, France

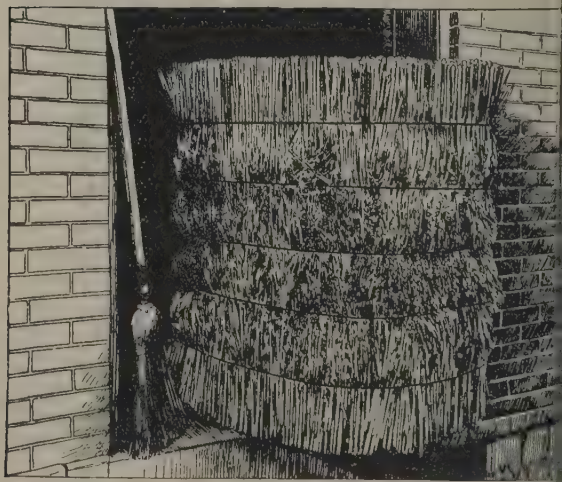
Propagation. Spain, Cyprus, Tunis, &c. Propagated by seed, sown at th rate of about 2 quarts per acre, or from 6 to 8 lbs. per acre, i rows 3 to 3½ feet apart, and the young plants thinned out t 3 or 4 ins. apart; or seed may be drilled in rows 3 fee

POOR AND GOOD HEADS OF STANDARD AND DWARF BROOM-CORN (after C. P. Hartley).

a, Poor head of dwarf with large centre. *b*, Head of dwarf enclosed in "boot." *c*, Good grade of dwarf for whisks. *d*, Long head of dwarf with characteristic weakness at point *x*. *e* and *f*, Good grades of standard hurl. *g*, Good head of self-working. *h*, Poor grade of standard because of heavy centre. *i*, Smutted head.

[*From "The Corn Crops," by E. G. Montgomery.*

STANDARD BROOM-CORN TABLED AND READY FOR HAULING.



A BALE OF BROOM-CORN.

(*From "The Corn Crops," by E. G. Montgome*

apart for dwarf varieties, 3½ feet apart for standard varieties, cultural treatment as for "Indian corn" or "maize" (*Zea Mays*) being recommended. Harvesting is advised when the plant is past full bloom and while quite green, as the brush loses colour and becomes brittle if allowed to ripen. Standard broom-corn, when ready for harvesting, is first "tabled," that is, turned down to the length suitable for brushes, as in the accompanying illustration ; the heads, with about six inches of stalk, are then cut by hand and threshed. The "brush" may then be stored in layers about 3 ins. deep for three weeks or so, afterwards being piled in greater bulk until thoroughly dry. The dwarf varieties are not necessarily tabled, but the heads are harvested, threshed and stored in the same way. The heads when dried are graded according to colour and length and put up into bales from 300 to 400 lbs. in weight. From 500 to 1000 lbs. of clean brush is a good yield per acre. Harvesting.

In Italy the fibre is graded into large and small ; the small is much cheaper and is used to fill out the interior of the brooms, the large being used for the covering. In Queensland three classes of brush are distinguished in the Trade—"Inside," generally not more than 17 ins. long, used for forming the inside of the broom ; "Cover," 17 to 20 ins. long for covering the inside and also for forming the shoulders, and "Hurl," ranging from 20 to 25 ins. in length, fine and straight, for the outside and finished covering of the broom. About 1½ lbs. of brush are required to make an ordinary broom and the grades are used in about equal proportions. The Italian fibre realised 10*s*. to 16*s*. per cwt. prior to 1916, when it realised 26*s*. At the present time (1928) on the London market the value is about normal. Fibre carefully graded. Three classes of brush : "Inside," "Cover," "Hurl."

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CHAPTER XIX

ON OIL PLANTS: FATTY OR FIXED OILS

Introduction.

THE Vegetable Oils of commerce are broadly separated into "Fatty" or "Fixed" and "Essential" or "Volatile." The first mentioned are with few exceptions obtained from seeds or kernels. The exceptions are chiefly olive oil (*Olea europea*) and "palm oil" (*Elæis guineensis*), in which the oil is obtained from the pericarp or outer portion of the fruit. The latter also yields an oil from the kernels. The method of extraction is by expression.

Seed-crushing centres.

It is claimed that the port of Hull is the largest seed-crushing centre in the world, the imports of all kinds in a year probably exceeding 700,000 tons Marseilles, Hamburg, Liverpool, London, &c., are also great centres of the industry. The Essential Oils may be obtained from any part of the plant, being contained in either roots, leaves or flowers, though rarely in the fruits. Here again a few exceptions may occur, as in fruits (often called seeds) of several umbelliferous plants, *e.g.* "ajowan" (*Carum copticum*). The method of extraction is usually by distillation.

The most important Fatty Oils of commerce are "copra" (*Cocos nucifera*), palm oil and palm-kernel oil (*Elæis guineensis*), ground nut (*Arachis hypogæa*), sesame or simsim (*Sesamum indicum*) and cotton seed (*Gossypium* spp.), all produced in tropical countries entirely under cultivation, excepting in this respect palm oil and kernels, which are produced in greater proportion from wild plants in West Africa.

Copra or Coco-Nut. *Cocos nucifera.*

Coco-nut oil is expressed from the dried kernel, known as "copra" in the trade. The chief sources of copra are the Philippine Islands and Guam, Ceylon, Straits Settlements and Federated Malay States, South Sea Islands (shipped by way of Australia and New Zealand), India, French Pacific Islands, Dutch East Indies, Mauritius, and Portuguese East Africa, to a total of about 350,000 tons annually. In addition to copra, large quantities of coco-nut oil are produced in the Philippine Islands, Ceylon and India, also the Straits Settlements, Java, Fiji, British Solomon Islands and Seychelles. From certain European countries large supplies are obtained, probably expressed from imported Copra and distinguished in the trade as "copra oil"; or it may be oil in course of transit from the countries of production. The oil is used for making soap, margarine, and, after being hardened (or hydrogenated), for manufacture of chocolate. In the course of the latter process the oil is deodorised. In India and various Eastern countries it is used largely for cooking.

Copra.

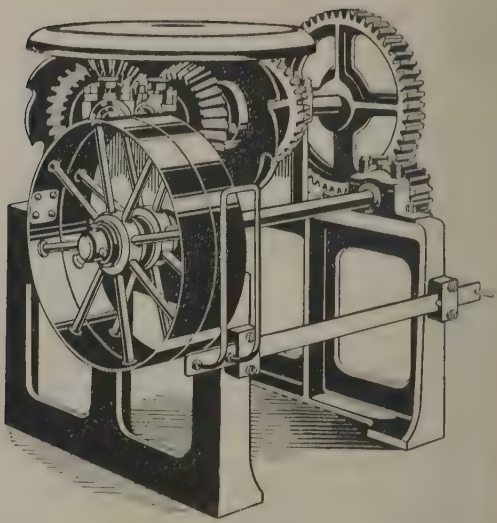
Countries of export.

Uses.

After the removal of the outer husk (see under Coir, p. 537) the nut is split into two by means of a machete, or the whole fruit may be split into three parts by means of a suitable machine such as the one illustrated. The milky contents are drained off and the halves or thirds laid open to the sun so that the copra can be partly dried whilst in the shell. The kernels (copra) are then more readily removed and thoroughly dried. In some countries the fresh meat is gouged out. The sun method of drying should occupy about sixteen days. Another process is by kiln drying on either grills over open fires made of the broken shells, or on solid masonry platforms: but in the former case the copra is discoloured by the smoke, and the drying, though quicker—taking approximately a day and a half—is more or less uneven. Drying may also be effected by means of a suitable apparatus

Removal of kernel.

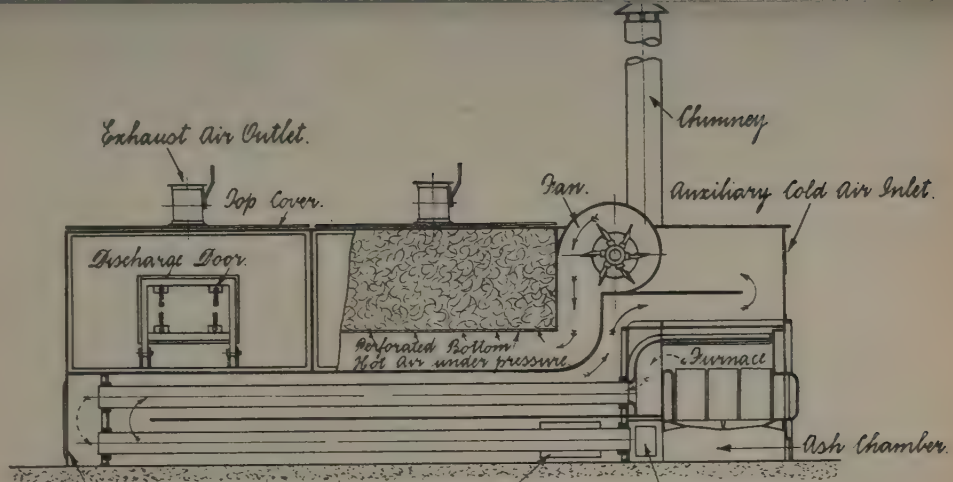
Drying.



COCO-NUT SPLITTER.

With this machine the husk and shell are broken into three pieces at one operation; up to 2,000 nuts can be dealt with per hour.

[*By courtesy of The Mirrlees Watson Co.*



COPRA DRYER.

This dryer is made in two sizes. (1) With a capacity charge of 6,000 nuts, producing about 24 cwts. of copra in 24 hours; h.p. required, 2. (2) Capacity 10,000 nuts, producing about 2 tons of copra in 24 hours; h.p. $2\frac{3}{4}$. The furnace is suitable for burning either wood or husks and shells. The fan draws the hot air (kept at 155° F.) from the heater to a chamber below the copra which is the only outlet, as shown by the direction of the arrows.

[*By courtesy of The Mirrlees Watson Co.*

with hot air at a temperature of 155° F. The plant illustrated is capable of drying a charge of copra in 24 hours, leaving only 5 or 6 per cent. of moisture in the product. After exposure to this heat, the dried product when slowly cooled is ready for putting into sacks for shipment. The copra oil, so-called, produced by modern methods in Europe, is regarded as the lowest grade, though the copra itself is usually graded according to country of origin and method of drying, the sun-dried process being the best; then comes the hot-air method, the best artificial means of drying (see p. 547), and the kiln or smoke-dried is the lowest grade.

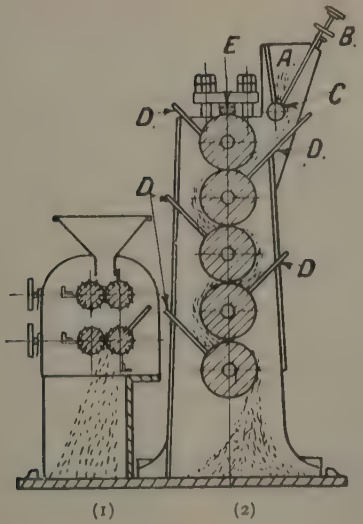
Grades of oil.

The principal grades of oil are "Cochin," "Ceylon" and "copra." The first mentioned is the best oil and may be applied to any superior coco-nut oil whatever the country of origin; but it is properly applied to superior quality oil, originally from the Malabar Coast, the oil being obtained from real sun-dried copra. Ceylon grade is usually second quality; it may be obtained as described for the best; but a good quality oil is produced by the aid of the modern mill methods, whilst "copra oil" as referred to above is the lowest market grade, the quality and quantity varying in accordance with the degree of perfection in drying. It is of importance that the nuts should be quite ripe and fresh to secure the best yield—50 to 75 per cent.—and the better quality oils. The native methods in India and Ceylon of extracting the oil by expression, though primitive, are quite efficient, the oil mills being of a simple type worked by oxen.

Methods of extraction. Native methods.

Modern mills.

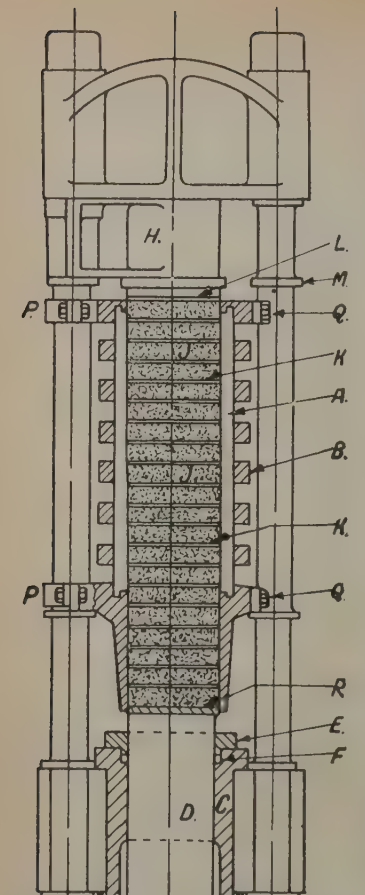
In the modern mills the main operations of obtaining the oil from the copra are (1) shredding or reducing the kernel to either meal or thin flakes in order to admit of (2) crushing, which must be done thoroughly if the maximum amount of oil is to be obtained, (3) heating or cooking, *i.e.* a temperature sufficiently high to evaporate all excess of moisture and to melt the oil so that it flows freely when in the press. It may be desirable to add here that the milling machinery for



REDUCING MILL, ROLLS MILL.

(1) For reducing the size of copra, palm kernels, castor seed, ground nuts, etc., and cake breaking before passing through the rolls. (2) For crushing—for which purpose the seed is placed in the hopper, *A*, the supply to the rolls being regulated by the slide, *B*, and feed roll, *C*; it falls upon the steel scraper plates *D*, and is deflected between the rolls and finally falls upon the base plate. Springs, *E*, are placed at each end of the rolls to give the necessary pressure. The feed should be regulated so that a constant supply of seed is passing through in a thin stream; if the feed is too heavy the crushing will not be so effective and the rolls will have to run empty until a further supply is required.

[*By courtesy of The Mirrlees Watson Co.*



OIL PRESS ("BAR-BOX" OR "CAGE" TYPE).

[*By courtesy of The Mirrlees Watson Co.*

Oil Press of the "Bar-Box" or "Cage" type with hard steel bars, *A*, held in a vertical position by steel hoops, *B*; the bars are recessed so that when doubled together there are openings between each, through which the oil can flow freely, but which are too fine to allow the meal to escape.

C, steel cylinder; *D*, ram; *E*, gland; *F*, leather ring; *G*, oil-collecting dish; *H*, revolving head to close the opening of the box.

To fill the press the head, *H*, is turned from over the box, and the ram, *D*, pumped up to within a few inches of the top, a thin steel plate is dropped on to the ram, and on this a round cloth mat is laid, a quantity of the cooked meal is taken from the kettle hopper and should occupy 2½ to 3 ins. of the box; on this is placed a cloth, then another plate. The ram is allowed to descend slowly during the repetition of the above until the box is completely filled with charges of meal, *J*, separated by cloths and plates, *K*. The use of the cloths is to assist the flow of the oil from the centre of the cake to the outlets in the bars, hold the meal from excessive spreading and prevent the finished cake from adhering to the plate. With some material such as copra, the cloths can be dispensed with.

When the box is full the opening is closed by the head, *H*, and pressure admitted to the ram, *D*. The oil runs down the box and is collected in the dish, *G*, from which it runs to a tank. When the oil ceases to flow, which takes usually about 30 minutes, the pressure is released until the head, *H*, can be removed. On returning the pressure the cakes are forced out at the top of the box, the cloths and plates being separated from them as they rise up. The cakes leave the box in a finished state, no paring or trimming of the edges being required.

When under pressure the side pressure causes the box to rise until the projection, *L*, on the underside of the head has entered the box. This allows the cakes to expand when the pressure is removed without binding the revolving head. The box is held by the stops, *M*, when pushing out the cakes.

For convenience in re-leathering the cylinder the box is clamped to one column at *P P*; when the stops, *Q*, are removed the box can be turned until clear of the ram. The gland, *E*, is raised by the jack screw until the old leather can be removed and a new one substituted. The thick plate, *R*, should always remain on the ram head when at work.

treatment of large seeds or kernels would be the same as described, including palm kernels (*Elæis guineensis*), ground nuts (*Arachis hypogæa*), castor seed (*Ricinus communis*), though in some cases, the two last mentioned particularly, it is advisable to resort to double pressing, the first with the material cold, which gives the best-quality oil, suitable for edible purposes in the case of the ground-nut, and in the castor seed suitable for medicinal use. The cold-drawn oil is made in Europe and the United States by several rather complicated processes requiring the aid of expensive machinery and skilled labour. The presses suitable for the treatment of castor seed are known as the "Premier" type (makers, Messrs. Rose, Downs and Thompson, Hull), the pressing boxes being perforated over their entire circumference with minute holes for the escape of the oil; the larger presses being constructed for a working pressure of 3 tons per square inch, the smaller presses for 2 tons per square inch. The shredding or reducing process is not necessary for treatment of small seeds such as "sesame" (*Sesamum indicum*).

Machinery.

The castor seed is fed whole, without any preliminary grinding, direct into the press, and treated at ordinary atmospheric temperature, thus producing the first quality of cold-drawn oil. The cakes made in this first pressing, after the oil has ceased to flow, are taken from the press and reduced to meal, which goes back to the kettle, and for this second pressing steam is admitted to the steam-chamber or jacket of the kettle, provision also being made to admit a small portion of live steam to the interior of the kettle should this be necessary in order to enable the remainder of the oil to flow more readily. The second pressing is carried out with the material heated to a temperature of about 180° F. There is another quality of oil also produced, by pressing the seed at a temperature of about 90° F. In treating the seed at ordinary atmospheric temperature the percentage of oil remaining in the cakes would be from 18

Castor seed.[1]

[1] Kew Bull. Add. Ser. ix. p. 609.

to 20 per cent. ; though when it is heated up to a temperature of 90°, the oil remaining in the cakes would be got down to about 10 to 12 per cent. ; but by pressing in this way the oil would be somewhat discoloured instead of being practically white as when pressed cold. All three of these qualities of oil are passed through a filter-press with an admixture of fuller's earth.

The cake after the extraction of the oil is not suitable for cattle feeding and is generally used as manure. (See page 346 for cultivation.)

Palm Oil and Palm-kernel Oil. *Elæis guineensis.*

The oil palm (*Elæis guineensis*) is a tree 60 to 100 feet high when fully grown, native of West Africa. It has been introduced by cultivation to Labuan, Federated Malay States, Sumatra, Java, Seychelles, Queensland, Jamaica and other tropical countries. In the Malay States and Sumatra the cultivation is well established and the production of the oil is of growing importance. There are several varieties found amongst the wild palms in West Africa, including (1) the "Hard-shell" palm nut (*Elæis guineensis* var. *communis* Chev. forma *dura* Becc.)—the nut is fairly thick and hard ; (2) the "Thin-shell" or "Soft-shell" palm nut (var. *communis* Chev. forma *tenera* Becc.), so called because the nuts are easily cracked owing to the very thin shell ; (3) the "King Palm" (var. *idolatrica* Chev.), also called the Sacred Palm as it appears to be held in veneration everywhere in West Africa, and the oil, sometimes called "holy oil," is used in native medicine ; (4) the "Perianth-fruited Palm" (var. *Poissonii* Chev.)—this variety has the fruit almost enveloped in a fleshy accrescent perianth or covering which, like the pericarp of the fruit proper, is coloured red, and also contains oil. Several other varieties and forms might be mentioned, but as none of them can be depended upon to come true from seed it will be advisable

Varieties of oil palm.

to confine this note to the one first referred to, which may be regarded as the type. It is found throughout West Africa, usually to the exclusion of all the others in many parts, and forms the greater percentage of the trade in oil and kernels. It is grown in Sumatra and Malaya, where good cultivation and selection have greatly improved the quality of the fruit, which has become known as the "Deli" type. The cultivation has developed within recent years so successfully that the production of the oil is likely soon to equal that of the West African trade, where (in 1925) the export of palm oil amounted to 132,524 tons, value £4,303,852, and the export of kernels 343,417 tons, value £6,217,428, and approximately the same in 1926, involving a turnover of the immense sum of £10,500,000.

Cultivation in Sumatra and Malaya.

Trade of West Africa.

Oil from the pericarp is an important food in West Africa, where it is also used for cooking purposes and to some extent as an illuminant. In Europe, palm oil (the trade name for oil obtained from the pericarp) is generally used as a lubricant and in the manufacture of soap and candles. Another interesting use to which palm oil is put is that of flotation in mining. The kernel oil or fat has a limited use in West Africa, but in Europe, where it is largely expressed from imported kernels, it is used for purposes much the same as those of coco-nut oil, in the manufacture of margarine, etc.; the residual cake being likewise an important feed for stock.

Uses.

The cultivation of the oil palm is fairly easy; it is propagated from seed, which should be specially selected from thoroughly ripe fruits. Sown in nurseries the seeds, when freshly gathered, take about three months to germinate, and they should be ready for transplanting when about six to twelve months old or when from 1 to 3 feet high. Light shade may be advisable during the early stages in the nursery, but when once the seedlings are established in the field shading would not as a rule be required. In the plantation the plants should be put out at distances of 30 × 30 feet triangular spacing (55 trees per acre) or 25 × 25 feet (69 trees per acre).

Cultivation.

OIL PALM (*Elæis guineensis*), GOLD COAST. COLLECTING FRUIT.
[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

GROVE OF OIL PALMS (*Elæis guineensis*), NIGERIA.

[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

The trees begin to bear when about 6 or 8 years old, up to which time the trunk may show little or no signs of development, though the leaves, 10 to 15 feet long, are fully grown, but the trees may be 50 to 100 years old before attaining the height above recorded. The above particulars afford a margin of safety, as it does not seem possible to give definite periods of germination, flowering and fruiting stages under all circumstances. From records made in Ceylon, Gold Coast, Seychelles and Nigeria,[1] plants put out in permanent places five to six months after sowing flowered at the age of two years and three months, and a small collection of first fruits was obtained nine months later, or about 3¼ years in all, whilst a Gold Coast record gives six years after planting out before beginning to bear fruits.

Fruiting period.

Rainfall and soil.

A good rainfall of 50 to 100 inches and rich, deep soil, or conditions similar to those advised for cocoa (*Theobroma Cacao*, see p. 145) are recommended for successful cultivation.

Green dressing or catch-crops.

Green dressing or catch-crops are advisable in order to prevent soil-wash. For the former, *Calapogonium mucunoides*, a light-loving plant, in the early stages, and *Dolichos Hosei*, a shade-loving plant, in the later stages, are recommended in Sumatra and Malaya.[2] For the latter, bananas, gambier, etc., may be suggested.

Pruning.

Pruning or reducing the number of leaves should be restricted to those that are spent and to such as are necessary to admit of harvesting the fruit-heads.

Pollination.

Pollination by hand may be advantageous in order to secure regular and good crops, but it is not advisable to overtax the trees in any one year.

Yield.

The yield of oil from the pericarp of normal fruits may vary according to whether it is extracted by the native method, by means of solvents or by machinery. From a one-acre enclosure of wild palms containing 44 fruit-bearing trees (one thin-shelled variety), the fruit collected

[1] See Kew Bull., 1920, pp. 199–205.

[2] Waters, "Oil Palm Plantations of Sumatra and Malaya" (Dept. Agric., Nigeria, 1926), p. 91.

(1)

(2)

(1) MALE INFLORESCENCE AND (2) FEMALE INFLORESCENCE OF THE OIL PALM (*Elæis guineensis*).

The flowers are unisexual—produced separately, but on the same plant.

[*From Malayan Agric. Journ., Sept.–Oct. 1927.*

FRUIT BUNCHES ON AN ARTIFICIALLY POLLINATED OIL PALM (*Elæis guineensis*).

Five years old.

FRUIT-HEAD AND LOOSE FRUITS OF OIL PALM
(*Elæis guineensis*)

from which the oil is obtained. The bunches are borne at the crown of the stem as shown on the tree, p. 554.

[*By courtesy of Messrs. Manlove, Alliott & Co.*

during each month of the year amounted to 290 bunches, giving 3,652 lbs. of fruit, the weight of oil extracted from a certain number of fruits was 7·14 per cent., and the general conclusion was that this acre of wild palms yielded 261 lbs. of pericarp oil and 497 lbs. of kernels. In general, under the best conditions the yield may average 1,680 lbs. of pericarp oil per acre.

From wild trees counting 69 trees (25 × 25 feet) per acre the yield by the first method per annum would be about 5,727 lbs. of fruit, which would yield approximately 410 lbs. of oil from the pericarp and 780 lbs. of kernels. Another estimate for full-grown trees is a yield of about 12 bunches of nuts annually, each bunch weighing from 20 to 56 lbs. An average-size bunch contains at least 200 nuts weighing from 7 to 21 lbs., and the annual yield in oil of one tree is about 7½ lbs.[1] This would give, at 69 trees per acre, approximately 520 lbs. In general it would seem that of the total weight of the fruits 5 to 7 per cent. of pericarp oil may be obtained by the native method of extraction.

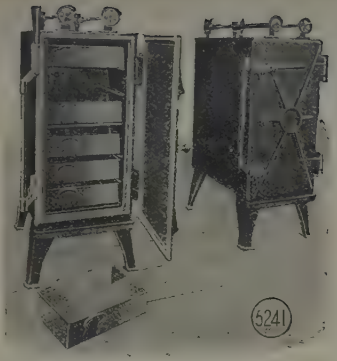
Extraction by solvents.

Native methods of extraction.

Extracting the oil by means of solvents, Ralston has found that 32·86 per cent. of oil from the pericarp may be obtained,[2] or 10·5 per cent. of the whole fruit. Briefly, the method in Southern Nigeria which produces a soft oil (so called in the trade) is that the fruits are separated from the bunch, boiled with water in an iron pot until the pericarp becomes soft, then turned into a wooden mortar and beaten with wooden pestles to separate the pericarp from the nuts. The mixture of nuts and fibre is then put into a circular pit lined with hardened clay, where the native treads out the fibrous matter adhering to the nuts; these are picked out and the fibrous mass remaining is squeezed by hand and thrown away. The oil rising to the surface of the water is collected and heated to evaporate any water present, and it

[1] Thompson, Kew Bull., 1909, p. 167.

[2] Farquhar, "Oil Palm," p. 23; Kew Bull., Add. Ser., ix, p. 740.



WET STEAM OVEN

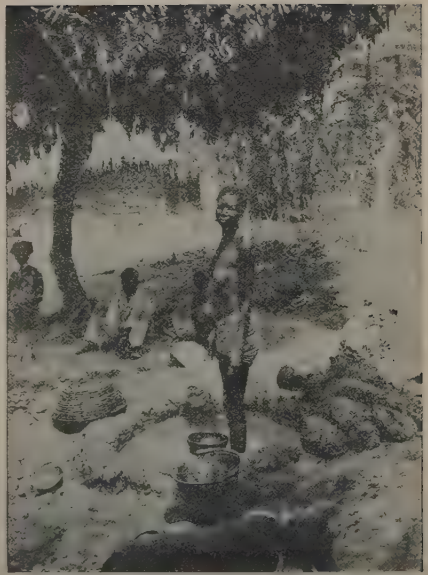
in which the freshly gathered fruits of the oil palm (*Elæis guineensis*) are steamed for one hour; to prepare them for the removal of the pericarp which contains the oil. The fruits are first placed in trays.

BOILING-PAN—FIRE HEATED

for use where steam is not available for the "Wet Steam Oven." The fruit is placed in a wire basket preparatory to boiling.

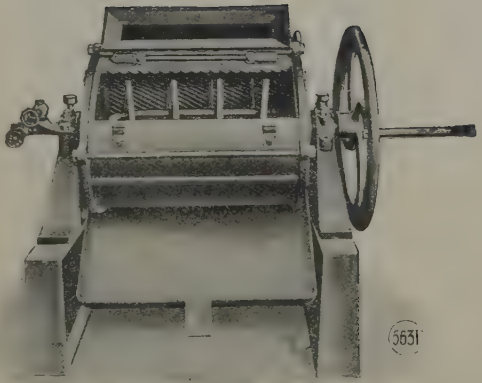
[*By courtesy of Messrs. Manlove, Alliott & Co.*

PREPARING OIL PALM FRUITS FOR NATIVE METHOD



EXTRACTING PALM OIL, NATIVE METHOD, NIGERIA.

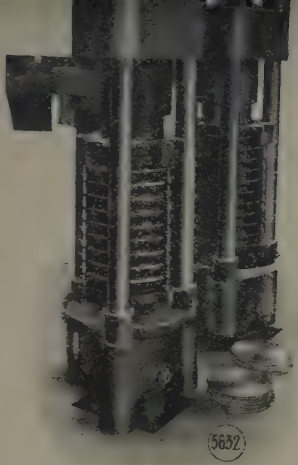
CRACKING OIL PALM NUTS, NATIVE METHOD, NIGERIA.
[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*



1.—Depericarping Machine.

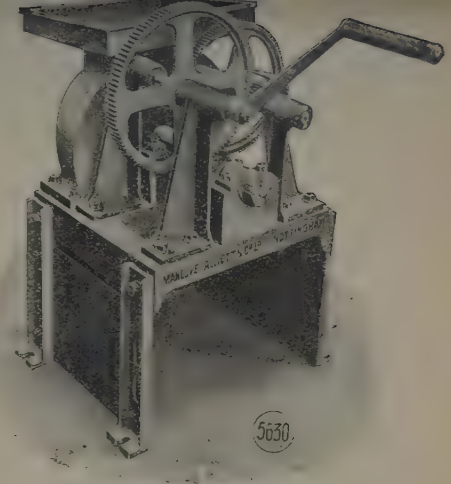
Fitted with a steaming device for keeping the fruit hot during the operation of removing the pericarp, which takes about half an hour. While the pericarp is being removed oil flows from the machine through spaces provided and is collected in a suitable tank. The

2.—Centrifugal Extractor which removes the major portion of the remaining oil and moisture and allows the nuts to be separated from the fibre.



OIL PRESS ("CAGE" TYPE)

into which the fibre is next placed and subjected to a pressure of 2 tons per square inch, which expresses the oil and leaves the fibre behind in the form of cakes.



NUT CRACKING MACHINE

in which the nuts are cracked when dried, after being taken from the centrifugal machine. The kernels and shells may be readily separated in a brine tank.

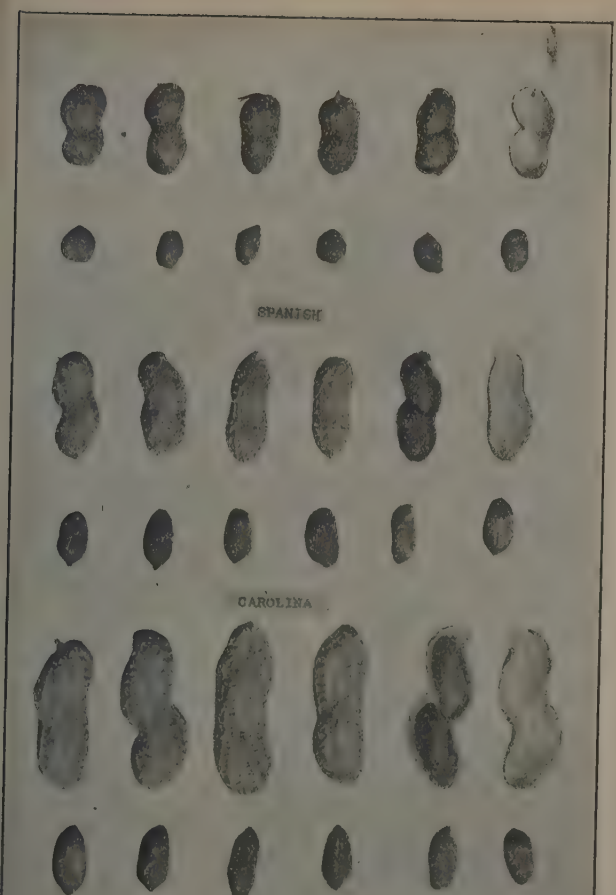
[By Courtesy of Messrs. Manlove, Alliott & Co.

is then ready for putting into the usual casks for ship ment. For cooking, the ripe fruits are boiled and the oi skimmed off. There is a fermentation process which pro duces a "hard" oil. The fruit is buried for a few days in a pit or covered up in some convenient receptacle such as a canoe. The fermentation which ensues loosens the pulp, a in the first stage of boiling in the process for "soft" oil and when this is effected the fruit is uncovered, water poure on to a sufficient depth, and the whole mass of fruits trodde out or bruised, which causes the oil to rise to the surface when it may be skimmed off and treated as before preparator to shipment.

Mechanical extraction.

Extraction of the pericarp oil by machinery is of compara tively recent introduction, but it is no doubt the method o the future where plantation produce is dealt with, and it i also being recommended in connection with the productio from wild trees. Perfectly ripe fruits as fresh as possibl are essential for treatment by machinery, and it is advisabl to extract the oil with as little delay as possible after gathe ing. A plant for hand power as illustrated is capable o dealing with 120 lbs. of fruit per hour, yielding from 18 2 lbs. of oil. Larger plants may be employed for treating ton of fruits in an hour, or ten tons a day on an average of ten-hour day. Power-driven palm oil plants with a capacit up to five tons per hour are also obtainable. The proces of extraction may vary somewhat, but the principles a described in the pages illustrated. In the larger or powe driven plants the oil extracted may be finally passed throug a special purifying apparatus forming part of the serie In some modern factories the processes include steam steri sation of bunches, double pressing of fruits by hydrau presses, and benzene extraction of residual oil in fibr The nuts are treated separately in a cracking machine a

[1] Auchinleck and Waters in "The Oil Palm Plantation Industry Sumatra and Malaya" (W.A. Agric. Conf., Nigeria, 1927), p. 3 Barnes, "Extraction of Oil Palm Products," *ibid.*, p. 46.



PODS AND PEAS OF THREE VARIETIES OF PEA-NUTS (*Arachis hypogæa*), "SPANISH," "CAROLINA" AND "VIRGINIA"

[*From "Southern Field Crops," by J. F. Duggar*

FIELD OF SPANISH PEA-NUTS.

[*From "Southern Field Crops," by J. F. Duggar*

the kernels crushed by the methods described under Copra. It is the practice to ship the kernels after drying to Europe for crushing, the facilities at present offered being better than those for shipment of the oil. Moreover, the kernel oil, like copra oil, is used largely for edible purposes, and the residual cake is likewise a valuable by-product of the industry, of importance for stock-feeding; both oil and cake would be more liable to deterioration in transit than the kernels.

Kernels usually crushed in Europe.

GROUND-NUT OR PEA-NUT. *Arachis hypogæa.*

The ground-nut is a small annual plant growing to a height of from 1 to 2 feet, or, according to the variety, trailing on the ground to the same length or more. In general appearance the plant resembles clover. Under cultivation there are several varieties and numerous forms, divided primarily into "bunched"—stems erect and compact—and "running"—stems more or less procumbent. The first includes "Spanish Bunch"; pods comparatively small, usually two-seeded. This is the variety usually grown in the Gulf Coast region of the United States for the production of oil, which in decorticated nuts amounts to 50 per cent. It is also recommended for confectionery or for dessert, because of the sweet seed, and as a forage crop. "Virginia Bunch" has large white pods, the kernels yielding a somewhat smaller percentage of oil than those of the foregoing. "Virginia Runner" is typical of the second group; it has large pods, usually two-seeded, and is largely grown in Virginia and Carolina. The African forms are generally included amongst those of running or of semi-prostrate habit, and these have been introduced to India where they have superseded the original or "Chinese" type of ground-nut. In Bombay small "Spanish Bunch" is recommended for growing on black cotton soils. In Java a "bunched" variety is cultivated largely for commercial purposes.

Description.

Varieties.

A BUNCH OF SPANISH PEA-NUTS.

[*From "Southern Field Crops," by J. F. Duggar.*

In general the ground-nut is grown in most tropical and in many sub-tropical countries, and our chief trade supplies come from the Gambia, French West Africa (Rufisque), Nigeria, Anglo-Egyptian Sudan, Mozambique, Kenya, China, Java, British India—Bombay and Coromandel; the volume of trade amounting to about 100,000 tons per annum, value nearly £2,000,000.[1] The best grades for the production of edible or salad oil are exported in the shell, and inferior grades, decorticated before export, yield an oil mostly used for soap making, &c. The imports of decorticated nuts are chiefly from Coromandel (£22), Bombay (£21 15*s.*), Chinese (£21 10*s.*), East African (£21 15*s.*), Niger (£22) and Java (£26 10*s.*)—the Java nuts are described as "hand-picked kernels." Undecorticated nuts come in from China (£22 10*s.*), Rufisque (Senegal) (£17 5*s.*) and Gambia (£17 2*s.* 6*d.*). The amounts within brackets are the prices ruling per ton in July 1927, and are quoted from the report of Messrs. J. H. Rayner & Co. of London, Liverpool and New York.

Trade sources.

Market prices.

The cultivation is comparatively easy, the main requirements being a tropical or sub-tropical climate with a light rainfall of 30 to 50 ins. and plenty of sunshine; a light, rich, sandy loam with a fair proportion of lime and careful and thorough tillage until the pods have buried themselves in the soil to ripen. It is recommended as a rotation crop with cotton, tobacco or maize, not only because the crop is an exhaustive one, but the change round is a preventive of disease. The best selected seed only should be sown, either in the pod or shelled at the time of, or shortly before, sowing. It should be sown in ridges about 2½ to 3 feet apart, the seeds being from 9 to 12 ins. apart. Sowing is commonly done by hand, but it is possible to obtain a machine for the purpose (see page 50). A crop matures in from four to five months according to the variety grown, and the proper time to harvest will depend largely upon local conditions. Usually harvesting is done by hand, but under a large acreage proper implements would be required, and it is

Cultivation.

Harvesting.

[1] This, however, is only a part of the trade, most of which centres in Marseilles.

NATIVE OIL PRESS, CRUSHING SESAME (*Sesamum indicum*), FEDERATED MALAY STATES.

[From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.

possible to obtain machines which dig, pick, clean and separate the nuts. A good yield per acre may vary from 1,500 to 3,000 lbs. of nuts (or a maximum 50 to 60 bushels) and 1 to 2 tons of the haulms or hay for feeding stock. Yield.

The oil content of the nuts varies somewhat according to variety, but 45 to 50 per cent. as quoted above for "Spanish Bunch" may be regarded as a good average. The hypothesis has been put forward that the percentage of oil will also vary according to whether the plant is grown within or without the tropics. Important centres of the crushing industry are Marseilles, Liverpool and Hull. In Marseilles the ground shells, known as "Soga Meal," are exported for use mixed with molasses for feeding cattle. Oil content.

The treatment for extraction of the oil is similar to that for copra or palm kernels, except that the undecorticated nuts require to be first cleaned or screened to remove dirt from the outer husk, and then after removal of the parchment-like skin passed through a hulling machine. The kernels, like castor seed, are first pressed cold in order to obtain the finest grade of oil. The cake from the first pressing is then passed through the reducer and rolls machinery, heated in the steam kettle to about 30° to 32° C., and subjected to a second pressing which yields more oil of an inferior quality. The double pressing gives a high yield of oil and the residual cake is an important by-product for stock-feeding. Extraction.

Sesame or "Sim-sim." *Sesamum indicum.*

Sesame is an annual plant, 1 to 5 feet high, believed to be native of tropical Africa, but widely spread by cultivation in the tropics and sub-tropics. The distribution is to some extent indicated by the following various common names: "gingelly" (India), "til" (Bengal), "beniseed" (Sierra Leone and other parts of West Africa), "bene" (French West Africa), "sesame" (E. Africa); "sim-sim" is applied in the Sudan and Zanzibar, "chitowe" and "mafuta" in Mozambique, and numerous others Description. Distribution.

might be mentioned. There is a large trade in the seed in Europe, Marseilles being an important centre. The home imports come chiefly from India, Nigeria, Iraq, Abyssinia, Sudan, East Africa, China, Japan, Asia Minor, &c., the trade amounting to about 8,000 tons, value about £190,000, or on the market the price may average £23 to £26 per ton —Chinese, for instance, being quoted at £26 15*s.*, East African as "sesame" and West African Colonies as "benni-seed" both quoted at £26 per ton.

Countries of export.

Market prices.

Cultivation. The cultivation is easy. The seed may be sown broadcast or in rows 1 to 1½ feet apart at the rate of about 10 lbs. per acre. The plant thrives in sandy loam and comes to maturity in from three to five months. It is advisable to sow at seasons that will admit of plenty of moisture in the earlier stages of growth, say for about two months, and drier conditions when the plants are flowering and ripening the seed. Harvesting may be done—while slightly under-ripe—by cutting the plants with a machete close to the ground, and stooking until dry; finally the seed is shaken out from the capsules. Two principal varieties are grown—"black-seeded" and "white-seeded," the oil from the white being more suitable for food, its principal use in the countries where grown, and the black for industrial purposes. A good crop is estimated at from 350 to 700 lbs. of seed per acre, or over a large area—in India, for instance, where 3,000,000 acres at least are under sesame—the average may be about 250 lbs. of seed per acre. The yield of oil is 45 to 55 per cent., and the treatment for pressing is much the same as described above, except that the seeds, being small, do not require any preliminary reduction before being put under pressure. A native oil-press for crushing sesame is shown at work on p. 572.

Harvesting.

Varieties.

Yield of seed and oil.

Cotton Seed. *Gossypium*—various species.

The cotton plant has been dealt with under Fibres, Chapter XVIII, and as a source of oil it remains only to

deal with the seed. This yields in crushing from 20 to 22 per cent. of yellow oil, suitable when refined for the manufacture of margarine, as a salad oil, and often so used as a substitute for olive oil. The oil also finds an important use in soap manufacture. Uses.

After ginning in special machines to remove the lint or cotton staple of commerce, most of the varieties of cotton seed have a covering of short fibre called "fuzz" or "linters" left on them. This in turn has to be removed by another special machine before crushing to extract the oil. But beyond this the treatment is similar to that of other edible seeds of small size. The residual cake is also of importance for feeding cattle. The "linters" are a valuable source of cellulose and of growing importance in the manufacture of paper and artificial silk. Preparation for crushing.

The chief sources of supply of cotton seed are Egypt, India, Brazil, Peru, Uganda, Anglo-Egyptian Sudan and Nigeria, the market prices in July 1927 being from 8*s.* to 9*s.* 6*d.* per cwt.; the total amount of seed imported into the United Kingdom (1924) exceeded 500,000 tons, to the value of more than £6,000,000. Over 3,000,000 tons a year are produced in the United States, but the oil is practically all extracted locally. Trade sources and market prices.

Sunflower. *Helianthus annuus.*

This is an annual plant with stems from 3 to 10 feet high, flower-heads disc-like, 10 to 20 inches across according to the variety, petals of the ray florets yellow. The seeds are rhomboidal in shape, $\frac{3}{8}$ in. long, $\frac{1}{4}$ in. broad or larger, set in leafy cups (the disc-florets) varying in colour—black, white, black-and-white striped or brown-and-white striped. There are several well-marked varieties grown for the seed, including "African Black Giant," "Black Seed," "Black Giant," "Russian" (Large, Mammoth, Tall, White), "Chinese Giant," "American Giant," &c. Probably native Description. Varieties.

of North America, common in Mexico and Peru, and cultivated in many tropical and sub-tropical countries.

Cultivation. The cultural requirements are chiefly a warm climate, moderate rainfall, light, rich and well-drained soil. Raised from seed sown at the rate of from 5 to 10 lbs. an acre broadcast, or in rows 3 feet apart, and the plants to develop properly should be thinned out as required to about 18 inches apart. The plants come to maturity in about Harvesting. four months, and should be harvested before becoming quite ripe. The seeds should be removed from the heads the same day as gathered if possible, an ordinary flail or a specially constructed machine being used for the purpose.

Yield of seed and oil. The yield of seed varies, and it is not easy to strike a fair average, but from actual figures quoted in different ways we have 900 to 1,500 lbs. per acre,[1] giving 15 to 20 per cent. of oil; 18 cwt. of good clean seed per acre,[2] giving 300 lbs. of oil, or 18 per cent. of the weight harvested; on average land 50 bushels to the acre,[3] yielding 1 gallon of oil per bushel. Yields well and gives about 1,400 lbs. of seed per acre.[4]

In crushing, the yield of oil from the kernels may be estimated at from 25 to 30 per cent.; the methods of expression being as described above. The oil is suitable for culinary and table purposes and for the manufacture of margarine, sometimes used as a substitute for olive and almond oils. The residual cake is a good feed for cattle, though it is found to dry harder than most oil-cakes, and is recommended to be ground as small as possible

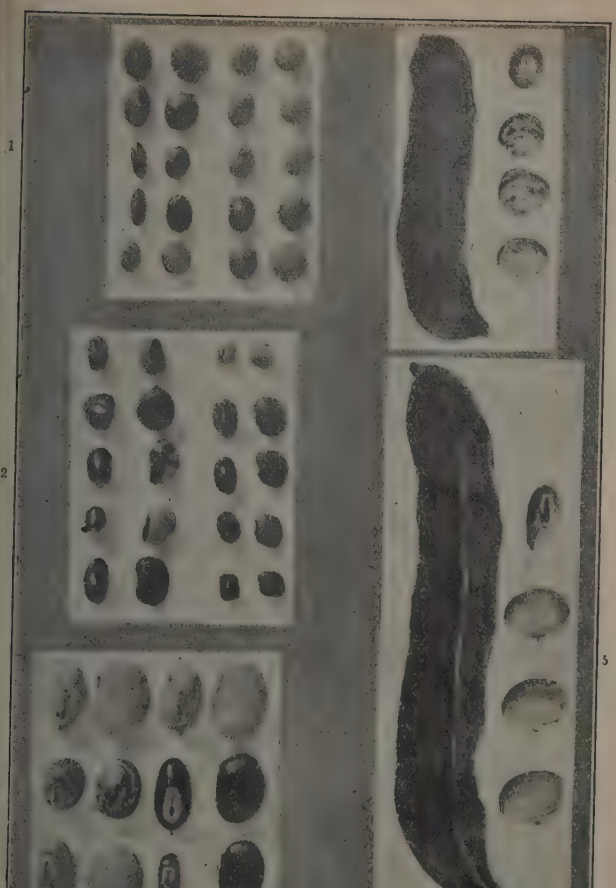
Storing of seed. before mixing with the ration. In storing the seed it should be heaped in comparatively small quantities to avoid overheating and turned regularly to keep it fresh and sweet.

The chief sources of the seed are Russia, Argentine,

[1] Cape Agric. Journ., p. 85; Bull. Imp. Inst., 1908, p. 84; Journ. Board Agric. (London), 1908, p. 370.

[2] Journ. Roy. Soc. Arts, 1903, p. 419. [3] *Ibid.*

[4] Sampson, "Rotation Crops with Cotton in East Africa" (1927), p. 16.



(1) "Soy Beans" (*Glycine Soja*); (2) "Cow Peas" (*Vigna Catiang*) (see p. 479 under Fodder Plants); (3) "Velvet Beans" (*Mucuna*); (4) pod and seeds of "Florida Velvet Bean" (*Mucuna Deeringiana*) (see p. 478); (5) pod and seeds of "Yokohama Bean" (*Mucuna*).

[*From "Forage Plants and their Culture," by C. V. Piper.*

Trade sources.

South Africa and Portuguese East Africa ; over 30,000 tons, to a value of more than £400,000, being imported in 1924.

Oil seeds of secondary importance.

The foregoing oil-seed plants are of first importance commercially, but the following are enumerated as being of special interest. They are not cultivated on the same large scale in the tropics, though efforts are being made to this end, and it is thought for various reasons, more particularly the importance, either locally or generally, of the uses to which the oils are put, that it would not be proper to omit them from the list under consideration. The selection includes :—

"NIGER" or "RAMTIL" seed (*Guizotia abyssinica*). An annual plant with black seeds, native of Abyssinia and tropical Africa, cultivated in India, where the oil is used for culinary purposes and for burning. The oil is well known in trade, but it is probable that Hull and Marseilles are the most important centres for crushing ; the seed being imported in limited quantities, chiefly from India. It yields about 40 to 50 per cent. of a yellow oil which has been suggested as a substitute for linseed oil in making soft-soap. The cultivation is approximately the same as for sesame (p. 573).

Description of Soy.

"SOY BEAN" (*Glycine Soja*). An annual plant with sub-erect or climbing stems 1½ to 4 feet high. The flowers are small and cleistogamous—that is, they do not open and are self-fertilised, the anthers producing pollen grains which form tubes growing directly into the stigma. Pods 1½ to 2 ins. long, ⅜ in. broad. Seeds 3 or 4 in each pod, spherical or nearly so, sometimes flattened about ¼ in. in diameter ; colour black, brown, yellow, green or mottled, according to the variety. Cultivated in China, Japan, India, America, warmer parts of Manchuria, &c. Attempts have been made to grow it on a large scale in tropical countries with little better results so far than what might be described as successful experiments. Under cultivation the seeds

may be sown in drills 1½ to 2 feet or so apart. When grown for forage, more particularly, the seeds may be sown broadcast. The chief requirements are a warm climate, good rich soil with a fair amount of lime, and thorough tillage. The beans should not be over-ripe before harvesting. An average yield is estimated at 50 bushels of beans and about 10 tons of haulms for fodder per acre.

The bean as a source of oil has been known and used for at least a hundred years in Japan, especially for its use in the preparation of the famous sauce known as "Soy." The soy bean, apart from the ground-nut, is the only one amongst the pulses that contains a profitable proportion of oil, about 18 per cent., and the extraction of the oil is perhaps the only important use to which it is put in Europe, for which purpose immense quantities are imported annually into British ports (London, Hull), German (Hamburg), American (New York), and Scandinavian ports, the greatest export centre being Manchuria. In July 1927 Manchurian beans were quoted at £11 7*s.* 6*d.* per ton on the English market.

Percentage of oil.

Trade sources.

The "CANDLE NUT," also known as "INDIAN WALNUT," "COUNTRY WALNUT," "LUMBANG" of the Philippines, "BAN-KUL NUT" of the French Colonies (*Aleurites triloba*). A tree 40 to 60 feet high, native of Polynesia and Malaya, distributed by cultivation to many tropical countries, including India, Burma, Ceylon, Hong Kong, Philippines, Mauritius, West Indies, East Africa, Cameroons, &c. Propagated from seed and planted out when large enough to handle at about 25 to 30 feet apart in plantations, in protected situations up to 2,600 feet above sea-level. The tree grows quickly and may bear fruit in from two to five years.

Distribution.

The kernels have been found to contain about 60 per cent of oil suitable for the manufacture of soft-soap, oil varnishes, paints, linoleum, &c. A ton of nuts may yield 150 gallons of oil. The cake cannot be recommended for

Yield.

feeding purposes, as it has a poisonous effect on cattle. It may be used as a fertiliser. As a source of oil this species is worthy of more consideration, and, being better suited to tropical conditions, it perhaps equals the "tung oil" tree (*A. Fordii*) in importance, although the latter is the more important source of "wood oil" now in commerce.

"BALUCANAG NUT" (*Aleurites trisperma*), native of the Philippines, where it is a source of oil similar to the foregoing.

Distribution.

The "TUNG OIL" tree (*Aleurites Fordii*). A tree native of China. Cultivated in Florida, and experiments are being made in Malaya, India, Ceylon, East Africa—including Kenya and Tanganyika—and South Africa.

Cultivation.

May be propagated from seed, which should be put in about 2½ ins. deep, raised in nurseries and planted out about 12 feet apart in rows 25 to 30 feet apart when about 1 to 2½ feet high or a year old. As soon as they are established they should be topped in order to form a bushy habit. The tree grows in comparatively poor soil; but a sandy loam with a good proportion of humus is perhaps the best, and good drainage is essential, together with a rainfall of 25 ins. or thereabouts. The tree will stand a moderate degree of cold, and in tropical countries situations should be selected at altitude

Climate.

where a sub-tropical climate at least can be assured. Trees begin to bear fruit in from two to five years after transplanting. Catch crops or a leguminous cover crop is advisable, to keep the ground in good tilth, and it may be necessary to use artificial manures. "Tung oil" or "wood oil" is largely used in the paint and varnish trade, some millions of gallons being required annually.

Jatropha Curcas, the "PHYSIC NUT," "PULZA," "PURQUEIRA" or "PULQUIERA" (Portuguese Cape Verde Islands); also known as "CURCAS NUT," and by various other names; common in many tropical and sub-tropical countries. A shrub or tree 10 to 20 feet high. May be easily propagated from seeds and by cuttings—*i.e.* 3 t

6 feet long, as is usual in the tropics—grows freely, or, to use a common expression, "like a weed" The plant may be cut or lopped to any desired height. The tree is often grown as a hedge plant, and in Madagascar it is recommended as supports for vanilla, for which purpose it may be planted in rows about 6 feet apart and 3 to 5 feet apart in the rows (see p. 309—Vanilla); but where the trees are grown chiefly for the seeds, from 10 to 20 feet apart would be desirable, allowing room for suitable inter-crops. Cultivation.

The seed is the source of "pulza oil" or "seed oil" of commerce—an important industry between Lisbon and Cape Verde Islands, where it grows wild, and large plantations are also under cultivation for the production of the seed for oil. It is calculated that 1,000 lbs. of seed give 640 lbs. of kernels, yielding by expression 260 lbs. of oil. This is used in the manufacture of soap and candles and medicinally in India. Both the oil and cake are poisonous. Yield. Uses.

The "SHEA BUTTER" tree (*Butyrospermum Parkii*). A tree 30 to 40 feet high, trunk in old trees 5 to 6 feet in diameter, native of West Africa—Gold Coast, Dahomey, Togoland, Nigeria, &c. It grows wild over dry regions or dry forest in comparatively poor soil, but as yet little can be said of its suitability for cultivation in plantations, and it is open to question, seeing that it is a slow-growing, hard-wooded tree, whether it should not be more a matter for conservation in forest areas than for agriculture. The experience in Dominica[1] goes to show that the seedlings are very slow in growth, healthy young plants three years old ranging from 12 ins. to 18 ins. in height, which it is believed agrees with the rate of growth of seedlings in its native habitat, where at times more vigorous growth is produced from root-suckers, by which the tree may be Habitat. Rate of growth.

[1] Ann. Rep. Agric. Dept., Dominica, 1916–17.

naturally reproduced. A tree about 14 years old in the same island was reported[1] as being in a healthy condition nearly 40 feet in height, flowering freely but fruiting sparsely. Wild trees in Africa have been recorded as flowering in January and the fruits ripening May to July or say four to six months for development of fruit.

Yield and trade sources.

The kernels yield about 50 per cent. of fat known in commerce as "shea butter," which, together with the nuts, is exported chiefly from Northern Nigeria and French territory in the hinterland of West Africa and the Sudan region. The imports of "shea butter" into the United Kingdom amount to a few hundred tons, and of "nuts" to several thousand tons annually.

Preparation of the oil.

The natives in preparing the butter for food remove the outer pulp of the fruit, dry the kernels in the shell and again after removing the shell in the sun or by artificial heat; the kernels are then boiled and the fat skimmed off the surface somewhat in the same manner as for the extraction of palm oil.

Habitat.

"MAHWA" or "MAHUA," "MOWRA" (*Bassia latifolia* and *B. longifolia*). Both trees, of like habit, grow in India, the first mentioned in the north, abundant in the Central Provinces, and the latter in Southern India. The two trees are a valuable source of oil, which is obtained from the kernels; suitable for soap-making, for which purpose it is used locally. There is also a large export trade in the seeds to our home ports and continental ports under the name of "mowra seed." The cake as a by-product is not fit for feeding, and it finds a use as manure or when ground up it is believed to enter into a preparation for treating lawns and golf-greens to destroy worms. The trees would appear to be of slow development, reported to become productive at from 20 to 25 years, and apart from forestry conditions, to which, perhaps, they would be better

Tree of slow growth.

[1] Ann. Rep. Agric. Dept., Dominica, 1913.

confined, they have been recommended for planting in open land devoted to cattle grazing.

"CHAULMOOGRA" (*Taraktogenos Kurzii*). A tree 30 to 70 feet high, native of the forests of Burma, often found in the sandy beds and along banks of the streams and swamps, and on loamy, flat country subject to inundation in the rainy season. The fruits are about the size of a large orange, with numerous seeds embedded in the pulp. The seeds yield an oil which has recently come into prominence for the treatment of leprosy, though for this purpose and the treatment of other skin diseases "chaulmoogra" oil has been known and used for many years. Interest in the possible extension by cultivation has not long since been aroused, and at the moment comparatively little can be said for the movement, as there are no plantations of sufficient duration on which conclusions might be based. The most recent work in the way of experimental plantations and discovery of suitable conditions of culture is afforded by the Agricultural Explorers of the United States Department of Agriculture (1919), and by the Department of Agriculture, Federated Malay States, at the Experimental Plantation at Serdang, where in 1923 experiments were being initiated with a view to planting up 25 acres. From seeds received at Singapore in 1921 several young trees were raised and planted out, on rather low-lying land at Serdang, in May 1924, when they averaged 1 ft. 10 ins. in height. The yearly records suggest slow growth; the trees under experiment by June 1926 varied from 2 ft. 6 ins. to 7 ft. 9 ins., or an average of 5 feet in height, but showed no signs of flowering. As to germination, this has been found to commence a month after sowing, continuing for three weeks, and the plants raised in bamboo baskets averaged 7 ins. in height about four months from the time of sowing, then showing a pair of true leaves in addition to the cotyledons. Another experimental experience is recorded in Dominica, where from seeds received through the Royal Botanic

Habitat.

Uses.

Experimental work.

Cultivation.

Gardens, Calcutta, in December 1920, young plants were raised which in 1926 were reported to have "not yet flowered," but they were expected to come into bearing when about eight years old. Two species of *Hydnocarpus* were included in the experiments at Serdang referred to above: (1) *Hydnocarpus Wightiana*, native name "kavatel," a large-sized—50 to 100 feet—evergreen tree of the West Coast of Kanara (Bombay), where the rainfall is more than 120 ins. per annum, to Travancore along the Western Ghats of South-Western India. The fruits contain about 20 seeds each. Seed has been found to germinate 15 days after sowing, and it is recommended to sow in places intended to be permanent, or sow in bamboo pots or baskets and transplant when about 6 to 12 ins. high (about 40 trees at 33 × 33 feet to 54 trees at 40 × 20 feet per acre), topping when about 6 to 8 feet high. The tree in its native habitat is found on deep alluvial deposits near fresh water rivulets, and also on mooram soils and laterite, from sea-level to an elevation of 1,800 to 3,000 feet. (2) *Hydnocarpus anthelmintica*, native name "maik rabao," a large tree 60 feet or so, of Siam, commonly found on the banks of rivers and estuaries. Fruits globular, 3½ to 4 ins. in diameter, containing from 30 to 40 seeds. Planted out in May 1923 at 30 × 30 feet (or about 55 per acre) in well-drained soil the trees were of an average height of 16½ feet three years later. Trees established in the experimental plantation above mentioned began to ripen fruits in six years from the time of sowing the seed.[1]

Habitat.

Cultivation.

Habitat.

Time of ripening.

In general it is found that the seed of all the above species soon loses its vitality, and when transporting it is advisable to pack in moist powdered charcoal, or in cotton bags overwrapped by oil-paper, and again by a thick wrapping of other strong material. Until the cultivation has been established on a commercial scale, no definite conclusions

[1] Kew Bull. *seq.* No. 2, 1927.

can be drawn as to the ultimate economic success of the species under experiment, but the outlook to all appearances at the moment is very promising.

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CHAPTER XX

ON OIL PLANTS: VOLATILE OR ESSENTIAL OILS

Introductory.

THESE are odoriferous oils, including some of our choicest perfumes, found in the various parts of plants—roots, bark, leaves and flowers; but, except on rare occasions, as already explained, not in the seeds—sometimes restricted to the flowers as in "ylang-ylang" (*Cananga odorata*); flowers and fruit (rind) as in citrus, orange, &c., fruit (often miscalled seeds as in "ajowan" (*Carum copticum*); leaves of "bay" (*Pimenta acris*); leaves of "cinnamon" (*Cinnamomum Zeylanicum*), and of *Cymbopogon* grass oils; bark of "cinnamon," unopened flower buds of "cloves" (*Eugenia caryophyllata*), and roots as in "vetiver" (*Vetiveria zizanioides*), or rhizomes as in "ginger" (*Zingiber officinale*), and many other instances might be quoted, but the above will be sufficient to illustrate the varied nature of the oils, and in the plants dealt with below, similar information is afforded. Only the most important of those in commerce are enumerated

The methods by which the oils may be obtained and separated are by expression or pressure, distillation, and extraction by means of various solvents, the details given being necessarily brief. For full particulars of the whole subject it would be advisable to consult the special works to which reference is made below. The first mentioned includes the well-known "sponge" and "ecuelle" processes, applied only to the citrus fruits amongst those here described—the peel of limes, lemons and oranges. The peel is sliced into

convenient sizes, two or three from a fruit, and each piece is pressed with one hand over an ordinary bath sponge held in the other hand, the sponge being occasionally squeezed into a receptacle for the oil. In order to keep the peel for preserving and the pulp for a supply of juice, the sponge method may be varied by halving the fruits, scooping out the pulp and then pressing the peel, held in the palm of the hand, against a sponge, turning it meanwhile until all the oil is given up.

Ecuelle process.

The **Ecuelle** in its simplest form is a saucer-shaped vessel, usually made of copper, studded on the concave side with short spikes about $\frac{1}{4}$ in. long, with a tube—which also serves as a handle—5 ins. or so long and about $\frac{1}{2}$ in. in diameter, opening from the centre of the saucer. The fruits are rubbed or rolled over the spikes with sufficient pressure to break the oil cells on the surface of the peel, setting free the oil which flows into the tube, from which it may be collected in larger vessels as required. The peel is sometimes treated by soaking in warm water, by which means any remaining oil is obtained, but this is of inferior quality.

Apart from the above hand processes a special oil-press may be used, the size and power of applying pressure varying according to the quantity of peel treated, which in this case is freed from the pulp, placed in a cloth and then subjected to the required amount of pressure. The resulting liquid may contain the oil, water and other substances, which, on being placed in long, narrow bottles, separates into the different layers, according to the specific gravity—oil on the top, water and heavier deposits below. After a few days the oil may be run off and purified by filtration, or in cases where not detrimental to certain oils, distillation may be resorted to.

Enfleurage.

Enfleurage is a process by which delicate flowers are treated for the absorption of their natural oil or perfume by means of purified lard, beef fat or olive oil. A layer of fat, about 1 lb., is placed on a sheet of glass which forms the

ORANGE RINDING, "ECUELLE" PROCESS OF EXTRACTING THE ESSENTIAL OIL, JAMAICA.
[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

base of a wooden tray (38 ins. × 24 ins. × 3 ins. approx.), and over it a layer of fresh flowers, which are left in contact with the fat for 15 to 24 hours, then renewed until the fat, at a normal temperature of about 15° C.,[1] is thoroughly charged with the perfume. From the pomade thus formed the concentrated perfume is extracted with alcohol. When olive oil is used, a coarse cloth is saturated with it and placed on wire-netting instead of glass, the flowers being laid on in the same way. The trays are laid one above the other in convenient tiers. A great number of trays require to be in use at the same time, involving the treatment of an enormous quantity of flowers, which contain only a very small percentage of oil. The process is expensive, slow, and requires considerable skill and experience for its successful application. It is done by manual labour throughout, except that a machine of comparatively recent invention can now be used for removing the petals or flowers from the fat, thus saving time and labour in the tedious method of picking them off by hand.

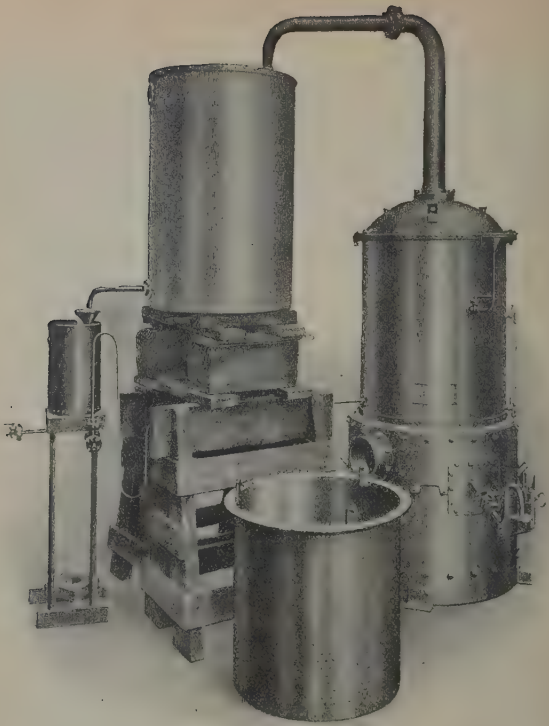
Maceration.

Maceration is a modification of the foregoing process. Flowers of a less delicate nature are put into vessels made of metal containing hot fat or oil—preferably olive—raised to a temperature of 60° to 70° C.,[2] constantly stirred mechanically or by hand, the exhausted flowers being replaced as before until the whole of the fat becomes charged, when the pomade is ready for treatment as described with alcohol.

Distillation.

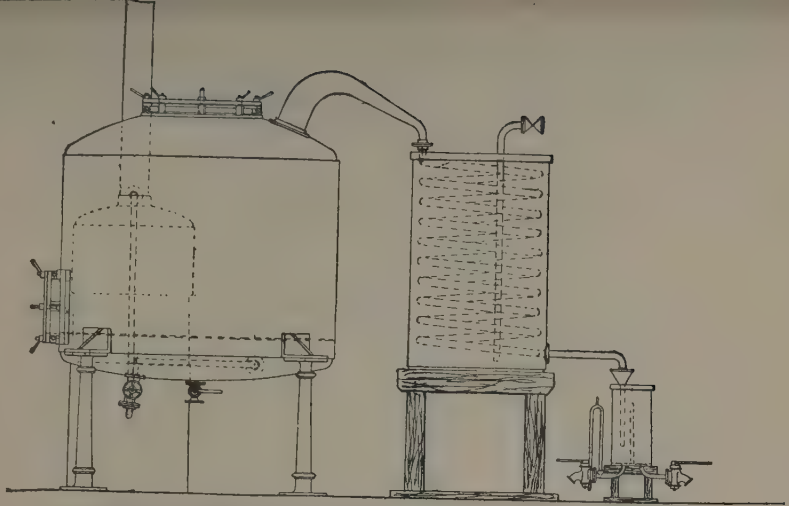
The process of **Distillation** is that by which most of the essential oils are obtained, and with the exception of the Citrus and Cassie oils, it is probably safe to say that the oil from the plants dealt with here, as coming under Tropical Agriculture, may be obtained in this way. On an extensive scale, the apparatus and machinery being of a highly technical character, distillation becomes almost entirely a matter for

[1] Perfumery and Essential Oil Year Book, 1916, p. 47.
[2] *Ibid.*, p. 47.



ESSENTIAL OIL STILL.

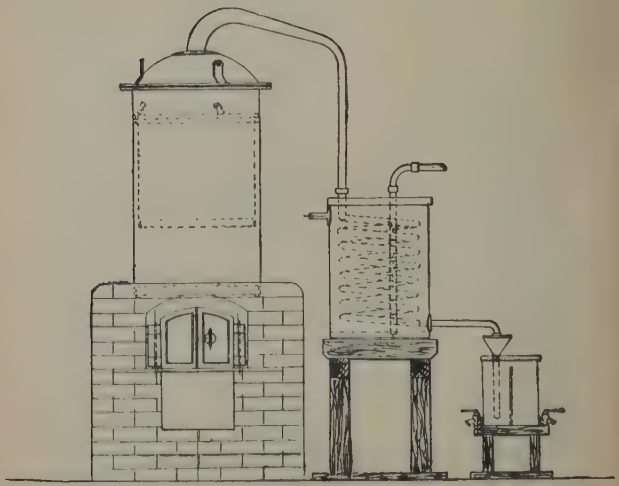
Made for treating "rosha" grass or "palmarosa" (*Cymbopogon Martini*) of India, but is also suitable for berries, leaves, etc. This still is self-contained and portable, the furnace is enclosed in a mild steel casing, and the whole arrangement is very compact. It can be made in various sizes, as required. The above illustration represents a direct fire heated still with furnace complete, as assembled in the works of Messrs. Blair, Campbell & Maclean, Ltd., before packing for shipment.



STILL FOR THE EXTRACTION OF ESSENTIAL OILS FROM LEAVES AND GRASSES.

Suitable for distilling "lemon grass" (*Cymbopogon citratus*) and similar large-leaved aromatic grasses. Diameter of still about 7 feet, but can be made to meet any requirements. Each still consists of a mild steel body supported on cast-iron columns, a copper lye pipe connecting the still to a copper condensing worm contained in a galvanised steel tank, and a Florentine flask made of copper. The mountings comprise charging door on the top, discharge door at the side for taking out the spent grasses, perforated false bottom, run-off cock, perforated steam coil and valve, and the necessary cocks on the Florentine flask for separating the water and oil.

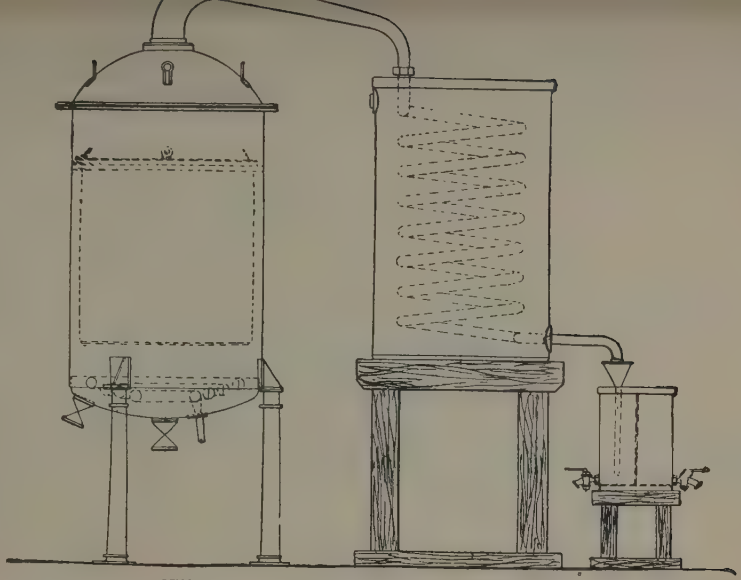
[*By courtesy of Messrs. Blair, Campbell & McLean, Ltd.*



STILL SUITABLE FOR TREATING BERRIES, SMALL-SIZED LEAVES, ETC.

which are placed in the container. When extraction is complete the container may be removed and emptied. The standard sizes range from 24 ins. diameter to 5 ft. diameter, and the capacities depend upon the class of material being treated. Similar in design to that shown on p. 593, except that instead of a steam coil for raising the steam necessary for extraction it is shown with a furnace for direct firing, enclosed in a brickwork setting.

[*By courtesy of Messrs. Blair, Campbell & McLean, Ltd.*



STILL FOR THE EXTRACTION OF ESSENTIAL OILS.

Suitable for treating the same classes of material as that on p. 594. Each still consists of a copper body supported on cast-iron columns, with a removable top cover connected by a copper lye pipe to a copper condensing worm contained in a galvanised steel tank and a Florentine flask made of copper. The mountings consist of an internal perforated container for holding the material to be distilled, copper steam coil and otherwise as in the still shown on p. 593.

[*By courtesy of Messrs. Blair, Campbell & McLean, Ltd.*

the engineer and specialist. The properties and constituents of essential oils may vary to such a degree that some modification in the application of heat or general treatment may be desirable to meet the conditions suitable in each case.

Modern stills.

The modern still illustrated on p. 597 is designed for the distillation of Essential Oils. It is fitted with a separator and connection for returning the watery distillate to the still, and takes a charge of approximately 8–10 lbs. of material. Apart from laboratory apparatus it is perhaps the smallest modern still of practical value. In general, distillation is effected by (*a*) boiling with water, care being taken to see that the whole of the material treated is covered with water; (*b*) by means of steam either direct or through steam coils or a steam jacket, the boiler in this case being separate from the still proper. Other stills are shown on pp. 592–5 and 598.

General principles of distillation.

It is proposed merely to illustrate the general principles and to describe more particularly the treatment adopted for such plants as *Cymbopogon*, including "citronella," "lemon grass," &c., that must be dealt with whilst the material is fresh or in the field.

Still used in Ceylon for citronella.

The process as commonly practised in Ceylon is described by Parry,[1] who states that a still 7 feet high and $4\frac{1}{2}$ feet diam. will produce from 350 to 450 oz. per day.

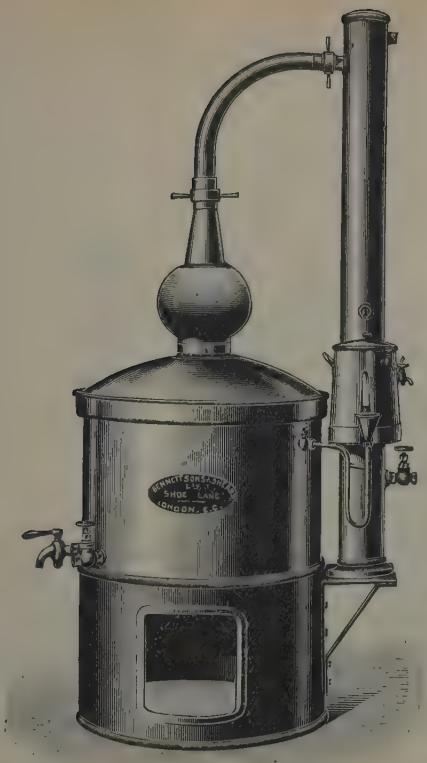
Java citronella.

In Java, in the distillation of "citronella" the requirements have been given as costing (in 1906) £250 for boiler, £85 for tank and condenser with pipe connection; a round tank 16 feet in diameter being considered sufficiently large to treat four crops a year off 200 acres if worked day and night.[2]

Malaya citronella.

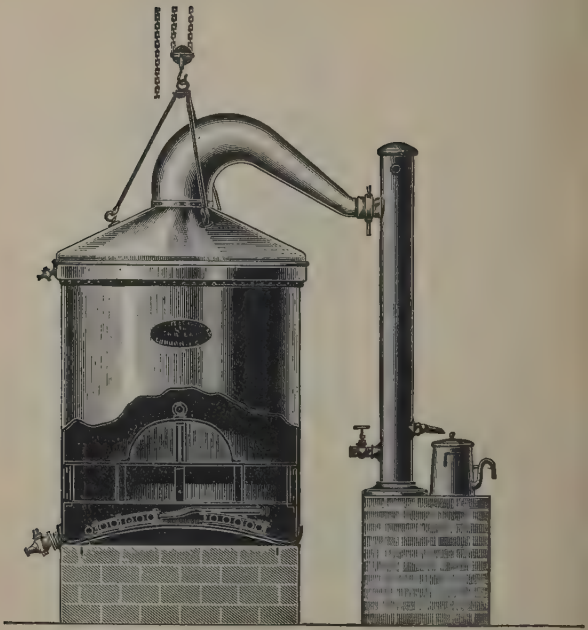
A distilling plant for "citronella" in Johore, Malaya, consists of a boiler large enough to supply a 20 horse-power engine, providing steam for distillation and for driving a

[1] "Chemistry of Essential Oils," *seq.*
[2] Kew Bulletin, 1906, p. 363.



ESSENTIAL OIL STILL

for extracting oil from leaves, seeds, bark, herbs, and for re-distilling the oil when separated. The illustration represents a still made of copper, with removable dome and water-seal joint, fitted with a perforated false bottom and steam coil below (or may be adapted for fire heat), also a perforated steam coil for free steam, condenser, separator, funnel and connection for returning mother liquor to the still. Mounted on a portable stand, complete for colonial use ; in sizes 50, 70, 100, up to 1,200 gallons capacity.



COPPER STILL FOR DISTILLING ESSENTIAL OILS FROM PLANTS

—"lemon grass" (*Cymbopogon citratus, C. flexuosus*) and other aromatic grasses, etc. Capacity 1,200 gallons, taking a charge of 1 ton of plants and 400 gallons of water. Diameter 6 feet; depth 7 feet. Fitted with discharge pipe and cock; copper steam heating coil, stays and steam valve; galvanised false bottom fitted with lifting rods and ring to admit of lifting it out of the still to discharge the spent leaves or material after distillation. Also made in smaller sizes.

LEMON GRASS (*Cymbopogon citratus*).

1, Entire plant (reduced). 2, Rhizome with tuft of sheaths (reduced). 3, Upper leaves of a barren tuft (reduced). 4–10, Inflorescence, spikelets and glumes (enlarged).

[*From the Collection, Royal Botanic Gardens, Kew, by permission of the Director.*

pump to supply water for cooling two stills, each capable dealing with 330 lbs. of grass at the same time; the co denser—a box lined with zinc—3 feet square, with a wor issuing from one side carried to a "florentine flask" f collection of the oil. Operating simultaneously a distillatio of 660 lbs. of grass lasting about two hours would yie about 0·69 per cent. or nearly 4½ lbs of oil.[1]

Distillation in India for "palmarosa" and "ginger grass."

The apparatus used in distilling the oil of "palmarosa (*Cymbopogon Martini*) in India is also of primitive type, bu the principle is the same. "The still is of iron or coppe and of cylindrical shape, having a sufficiently large openin at the top to allow of the charge being introduced. It i also often fitted with handles for transport purposes. Th cost of a copper still is about Rs. 400, and that of an iron still Rs. 40 to Rs. 80, while the life of the former is put a ten years as against one to three years of the latter. The size varies—one of 40 gallons capacity takes 240 lbs. of dry grass per charge, or one of 12 to 14 gallons capacity takes 80 lbs. of grass per charge. The capacity of the condenser (connected with the still by a pipe made of bamboo) varies according to the size of the still and is capable of holding anything from 8 to 15 gallons." The still is either built in and covered with mud up to the neck or is simply supported on stones over a fire-grate by which direct heating is obtained. "It is charged with grass and cold water in proportions of one to four by weight. The fire is then put under the still, and the distillate commences to come over within ¾ to 1½ hours according to the capacity of the still and the size of the grate." One still is described as taking 100 lbs. of dry "motia" grass and 45 gallons of water. "Starting with the boiler cold, the distillate comes over after an hour's heating, continuing to do so for about another hour." In another case, in a still taking 240 lbs. of dry grass and 40 gallons of water, the whole process takes four hours. The

[1] Bull. No. 10, 1907, Chambre d'Agric., Cochin Chine: Agric. News, Barbados, Sept. 1908, p. 302.

distillation completed, the bamboo pipe is disconnected at the still head and the oil collected from the condenser. This is done by filling the condenser to the brim with water and skimming off the oil by transferring the whole distillate to a circular iron tube where it is made to revolve with the aid of a spoon, the oil which collects in the vortex being taken off with the help of a ladle and transferred to a kerosene tin or an iron drum according to the quality of the oil."

Good supply of water essential.

It is advisable to erect the distillation plant close to a good supply of water for convenience in the distillation process and cooling the condenser.

Steam and direct fire-heating in distillation.

Experiments in steam distillation instead of by direct fire heating go to show that the above simple methods are capable of improvement and increased yield; but the chief advantage is calculated to achieve "economy of fuel and facility in regulating the duration and rate of distillation."[1] See illustration, p. 592.

Citrus oils.

CITRUS OILS :—LIME OIL. *Citrus medica* var. *acida*. LEMON. *C. medica* var. *limonum*. ORANGE. *C. Aurantium*.

LIME OIL. *Citrus medica* var. *acida*.

Lime oils.

The lime has been treated very fully in the present work, including extraction of the juice from the fruit, on pp. 215–219, and it remains only to add notes on the oil. This is exported chiefly from Dominica, British Guiana, St. Lucia, Trinidad and Montserrat, either hand-pressed (nominal value in August 1927, 42*s.* 6*d.* per lb.) or distilled (quoted at 29*s.* to 30*s.* per lb.). Oil of limes is obtained from the peel or recovered in the course of preparation of the concentrated juice, or of the citrate by distillation, and accordingly inferior to that obtained by expression; but the concentrated juice for the production of citric acid appears to be the more

[1] Pearson, Indian Forest Records, V., Part 7, 1916.

important product, and the oil from the juice a by-product in most of the countries growing the West Indian lime. The best hand-pressed oil in commerce is obtained from the variety *limetta*, or the Italian lime, though the oil from the peel or rind of the var. *acida* also realises good prices. By the "ecuelle" process the fresh limes must be treated as soon as possible after being collected in the manner above described. A certain amount of water is collected with the oil, but this is separated readily on standing in the collecting vessels or bottles for a short time. The oil is then stored in glass containers until the "limettin" in it is deposited, which may take three or four weeks, when, after filtering through paper, it is placed—usually in copper containers—ready for shipment. Galvanised iron casks or drums may also be used.

West Indian lime.

Italian lime.

A barrel (cubical content 4·5 feet) of limes weighs about 160 lbs., and may contain 1,600 fruits, from which the yield of oil by the "ecuelle" process is, on the average, 1·75 to 2 ozs. The yield of distilled oil from the juice during concentration is 0·426 oz. per barrel, or about 4 lbs. from every 100 gallons of juice.[1] Lime oil is used in perfumery and soap manufacture.

Lemon Oil. *Citrus medica* var. *limonum*.

Lemon oil.

The supplies of this oil come chiefly from Sicily and Calabria, obtained almost exclusively by the sponge method of extraction. The yield may vary according to locality and season; but the average is estimated at from 0·7 lb. to 1 lb. and possibly 1½ lbs. of oil from the peel of 1,000 lemons. Prices quoted for lemon oil in July 1927 were 7*s.* 3*d.* to 7*s.* 6*d.* per lb. Distilled oil of lemon comes from California, the quoted values for the same date as above being 5*s.* 9*d.* to 6*s.* per lb.

The lemon has been introduced, however, into many

[1] Kew Bulletin, Add. Ser., ix., p. 132. Bulletin Imp. Inst., 1915, p. 73.

countries, including Australia, Jamaica, East Africa, S. Africa, Florida, California, &c. In some cases it has become a commercial asset, and there seems to be no reason why it should not be a more productive source of the oil. The cultivation is much the same as for the lime (p. 215).

There are numerous varieties, including the "Genoa," largely imported into this country, a dwarf, thornless tree and one of the best; "Sicilian," probably our most important source for fruit and oil; "Eureka," reported (Hume) to be one of the best varieties grown in California, and the ordinary "rough" lemon of France, commonly recommended as a stock for growing good varieties of orange. In Rhodesia, where it has been introduced, it has become naturalised and practically runs wild in the Mezoe River region. The fruit, though used locally, is not of value for export, but it might be developed as a source of oil.

SWEET ORANGE. *Citrus Aurantium.* BITTER ORANGE. *C. Aurantium* var. *Bigaradia.*

Sweet and bitter orange oil.

The details given for the pressing and preparation of oil of lemon apply to the orange. The best oil appears to come from Sicily, but Jamaica also figures in the exports for sweet orange oil, a distillate being quoted at 8*s.* 6*d.* a lb. in June 1927, when Sicilian Sweet (hand-pressed) realised 9*s.* 9*d.* per lb.

Oil of "neroli."

Oil of "neroli" is distilled from the sweet and bitter orange flowers, in the South of France chiefly, from ½ to 1 gram of oil being obtained from a kilogram of flowers, or about 0·05 to 0·1 per cent.[1]

AROMATIC GRASS OILS. *Cymbopogon* spp.

The most important grass oils of commerce, except "vetiver," belong to the genus *Cymbopogon* (*Andropogon*), and include:—

Cymbopogon oils.

"Citronella" (*Cymbopogon Nardus*, Rendle; *Andropogon Nardus*, Linn.).

[1] Parry *seq.* and Radcliffe *seq.*

"Lemon grass": West Indian (*Cymbopogon citratus*, Stapf). East Indian (*Cymbopogon flexuosus*, Stapf).

RUSA GRASS: "Palmarosa" (*Cymbopogon Martini*, Stapf; *Andropogon Martini*, Roxb.). "Ginger grass" (*Cymbopogon Martini*, Stapf, var. *Sofia*).

"Vetiver" (*Vetiveria zizanioides*, Stapf; *Andropogon muricatus*, Retz).

CITRONELLA. *Cymbopogon Nardus*, Rendle.

"Citronella." A tall, robust plant, upwards of 3 to 5 feet high, with broad leaves, known only under cultivation.

Countries of production and export. It is grown in Java, Ceylon and Malaya, whence the oil is chiefly exported. Ceylon is probably the most important country of production, 36,000 acres being under cultivation; the quantity exported in 1926 totalling 1,431,351 lbs., value 1,774,326 Rs.[1] A recent quotation on the London market gives 1*s.* 4¼*d.* to 1*s.* 4½*d.* for spot transactions, and 1*s.* 3¾*d.* to 1*s.* 3½*d.* c.i.f. for shipment.

Uses. The oil is used largely in perfumery, scenting soaps, &c., and it has been recommended as a preventive against the bites of mosquitoes and leeches.

Cultivation. The cultivation of this grass is simple; it is usually propagated by division of the roots—seed rarely being produced, due probably to the constant harvesting of the leaves—planted 2 to 3 feet apart in rows. Soil is of secondary consideration provided it is open and well drained, but it thrives best in rich, open soil in a climate with a good or heavy rainfall. The leaves are ready for cutting about eight months after planting, and about two cuttings a year may be obtained, yielding about 40 lbs. of marketable oil per acre per annum.[2] Other estimates recorded[3] are that the "yield in Ceylon in the first and principal season (July to August) from 16 to 20 bottles (of 22 oz. each) per acre, and from 5 to 10 bottles per

Yield.

[1] Handbook of Ceylon, 1926, p. 101.
[2] *Ibid.*, p. 99.
[3] Gildemeister and Hoffmann, "Volatile Oils."

acre for the second season (December to February), varying according to weather, age and locality of the plantation." "The yield has been 1,282,471 lbs. of oil from about 40,000 to 50,000 acres. In the Malay Peninsula about 30,000 lbs. of oil from about 2000 acres, or from 110 to 440 oz. of oil per acre, according to season, have been obtained." In Johore (see the description of still, p. 596), it was calculated that each acre yielded from 10 to 12 tons of "citronella" grass per annum. These variable yields are given as it does not seem possible to estimate exactly what the annual yield will be in any particular area, and the safest records are averages for large areas under cultivation. Replanting is advisable after about twelve years, and the plants are recommended as a catch crop in rubber and coco-nut plantations, cacao, &c., the first life of the "citronella" plantation thus lasting approximately until the ground gets covered in by the trees, or at least affording substantial return up to the time the main crop becomes profitable. In Malaya the planting of "citronella grass" is recommended as a preventive of soil-wash.[1]

Replanting.

LEMON GRASS. *Cymbopogon citratus*, Stapf.

This grass is also known (by translations of the native names) as "orange grass," "perfume grass" and "camphor grass." It is a perennial, propagated by division of the roots; grows freely in well-drained soil, and in general the particulars of cultivation given under "citronella" would apply in this case. The plant is grown almost all over the tropics, and in the many countries to which it has been introduced it is used for decoration, commonly for bordering walks. *Cymbopogon flexuosus*, Stapf, the "Malabar" or "Cochin grass," is understood to be the source of "East Indian lemon grass oil," and practically all the lemon grass oil of commerce is held to be of East Indian origin, because of its superior quality. It was quoted in July 1927 at

"Lemon grass."

Cultivation as for "citronella."

[1] Perfumery and Essential Oil Record, April 1924—"The Utilisation of Citronella Grass in Malaya," pp. 120–121.

Market prices. Centres of production.

3*s.* 6*d.* per lb., the chief centre of production being Tinnivelli and Travancore in India; also exported from Cochin and Quilon.

Oil content greater in young leaves. Citral content greater in old leaves.

It has been found (K. de Jong) that the young leaves contain the largest quantity of oil, becoming less as the leaf gets older, but on the other hand the citral content increases, and it is on the citral value that the oil is usually sold. The citral content of lemon grass, however, may differ for various reasons to which it is often difficult to assign a cause.

Deterioration in storage.

It has been found to oxidise readily and to decompose on keeping, &c. Parry has found that the West Indian oil kept in iron drums for several years showed a decrease in citral value of 4 to 5 per cent., and that East Indian oils during the voyage to Europe will sometimes lose 2 per cent. or more. Some variations in this respect are also shown in the following bracketed percentages; the localities mentioned may also serve to show the range of "lemon grass" under cultivation:—Ceylon (76), India-Tyrna (72·5), Cochin (84·5), Mariana (73), Uganda (64·5 to 75), Bermuda (40), Montserrat (74), New Guinea (65–78), Mayotte (87), Seychelles (76–81), Formosa (54–76), Celebes (69).[1]

"Cultivated" and "wild" "lemon grass." Uses.

The distinction has been drawn of "cultivated" (*citratus*) and "wild" (*flexuosus*) between the two plants, and the oil is said to be distilled from both grasses.

"Lemon grass oil" is used in perfumery, in the manufacture of sprays for disinfecting and freshening the atmosphere of theatres and other public buildings, and in the manufacture of "ionine" (from the citral), the basis of violet perfumes.

Rusa or Rosha. *Cymbopogon Martini* Stapf.

Rusa grass is a native of India; the name here given is that under which it is known in Hindustani; but in the

[1] Chemist and Druggist, July 30, 1927, p. 161.

course of trade in the oil it has become known as "East Indian Geranium" and "Turkish Geranium." Botanically there are two varieties, namely, *Motia* and *Sofia*, the oils of which are known commercially as "palmarosa" and "ginger grass" oil respectively. The plant, that is to say the species, is widely distributed in India, being generally found in dry and hot localities; the more important areas in which the oil of commerce is obtained are the Bombay Presidency, Central Provinces, the Berars and certain Native States in Central India.[1] The variety *Motia* is reported to be found on bare hot slopes, generally in single clumps a foot or two apart, forming open grass-land in valleys near water-courses and on the northern or shady side of hills, while the variety *Sofia* is stated to grow wild in denser, moist areas or in poorly drained situations, gregarious and in some cases densely covering considerable areas.[2] Again, it has been stated that *Motia* is usually confined to the higher hill slopes while *Sofia* is more common in the plains and on plateau land in the hills,[3] but the two varieties are not infrequently found growing together.

Rusa grass varieties. "Palmarosa," "ginger grass."

Habitat of varieties.

Palmarosa oil (*Motia*) on the London market was quoted (August 1927) at 9*s.* 6*d.* per lb. for spot transactions, and 9*s.* 3*d.* for shipment c.i.f., while "ginger grass" oil (*Sofia*) was valued at the same time for spot transactions at 7*s.* 3*d.* and 7*s.* per lb. c.i.f. In 1906 the former was said to command double the price of the latter and that it was exported chiefly to Turkey for mixing with "otto of roses."[3]

Market prices.

The oil is distilled from the flower and leaf, only small quantities being obtainable from the stem itself. The flowers and upper third of the stem are collected in September and October and tied into bundles or "pulas" of about ¼ lb. each. This collection is either distilled in a partially green state or the flower head and portion of the

[1] Watt, "Commercial Products of India."
[2] Pearson, Indian Forest Records, V. Part 7, 1916, p. 2.
[3] Stapf in Kew Bulletin, 1906, p. 341.

Distillation.

stem are carefully dried in the shade before distillation, when they may lose 20 to 40 per cent. in weight according to the degree of drying before being treated.[1] The methods of distillation have been described above. The yield may vary according to the freshness of the grass or care taken in drying, and proportion of flowers to leaves, the flowers containing a greater percentage of oil than the leaves: but it has been found that a still charged with 20 gallons of water and 280 lbs. of flowers and stalks—the latter cut to one-third of their length when green—yielded 12 to 14 ozs. Carefully dried flowers yielded 8 to 10 ozs., and flowers which had been carelessly dried and collected yielded 4 ozs., or a yield of 0·31, 0·28 and 0·14 per cent. respectively. A yield of approximately 1 per cent. of oil has also been recorded.[2]

Yield of oil.

Production in India from wild plants.

The production in India also appears to be exclusively from wild plants and it is classed as a minor forest product. The areas where the grass is worked are leased by the Government; but considering the readiness with which the other species of *Cymbopogon* grow there, the plant is included here as being one of those that come near the borderline of forestry and agriculture, and there seems little doubt that it would respond successfully to cultivation.

Vetiver Root. *Vetiveria zizanioides* Stapf.

This plant is also known as "khus-khus" or "cus-cus-root," native of tropical Asia, where it is found wild and cultivated. Introduced by cultivation to tropical America, West Indies, tropical Africa, Reunion, &c. The aromatic roots are the source of the "vetiver" oil of commerce. It is distinct amongst essential oils by its viscid character, and it is commonly extracted in Europe from imported roots. The oil was quoted in June 1927 at 32*s.* 6*d.* to 33*s.* per lb.

"Vetiver" oil.

[1] Pearson, *loc. cit.*, p. 6. [2] *Ibid.*, pp. 8–9.

The plant is easily propagated by division of the root-stock ; it requires a warm climate and thrives in moist situations or near river banks. Planted out in rows from 3 to 5 feet apart, an acre in the second year after planting will yield from 1 to 1½ tons of clean root. The distillation is slow, each charge taking 12 to 16 hours owing to the low volatility and the great viscosity of the oil. The yield varies, 100 lbs. of roots yielding about 9 or 10 ozs. of oil (Piesse), or only 2 ozs. are obtained (Watts); other observers give 0·4 to 0·9 per cent.; but probably about 1 per cent. is the normal average.[1] Propagation. Yield of oil.

Vetiver oil is used in perfumery and the finest roots are made into small bunches for putting away with clothing, and the powdered root is an ingredient in sachet powders. Uses.

Patchouli. *Pogostemon Cablin.*

A shrub, 2 to 3 high, with fleshy leaves, 2 to 4 ins. long, 1½ to 3 ins. broad; native of the Philippine Islands; cultivated in the Straits Settlements, Java, Bourbon, Mauritius, &c. Description

The leaves from which the oil is obtained are imported into Europe—Grasse especially. The oil comes into the London market from Penang, Johore and Seychelles, quoted (July 1927) at 36*s.* 6*d.* to 37*s.* 6*d.* per lb., also from Java, recent quotations from this source being 34*s.* to 35*s.* per lb. Patchouli oil distilled from leaves. Market prices.

The cultivation is comparatively easy, the main requirements being a rich, well-drained soil, a hot climate and a good rainfall, or irrigation in dry weather. Manuring will also be necessary to keep the ground in good tilth when the plantation is well established. The inflorescence is a spike, 3 to 6 ins. long; the plant appears to flower but rarely, or not at all under cultivation, and, accordingly, reproduction by cuttings in the nursery is advisable. These if kept shaded and watered would strike root in a month or six weeks and may then be planted out about 3 feet apart in the plantation. From five to six months later leaves may Cultivation.

[1] Parry, "Chemistry of Essential Oils" (2nd Ed.), p. 185.

be collected, yielding about 8,000 to 9,000 lbs. per acre in a green state. They require to be dried in a cool, airy room or shed for about ten days, when they will lose about 75 per cent. in weight. A second cutting may be taken in about six months' time and dried with the same result, thus yielding a ton or more of leaves per annum. The yield of oil from a ton of leaves may be from 13 to 15 gallons, or one pikul (133⅓ lbs.) of dried material would give about 2 lbs. of oil. Parry gives a yield [1] of 2 to 4 per cent. of oil.[2] The leaves may be shipped, carefully packed, for distillation in the country of import or the oil distilled on the spot, being stored meanwhile if occasion demands.

Yield of leaves and oil.

Musk Seed. *Hibiscus Abelmoschus.*

A shrub 3 to 5 feet high, cultivated in India, Egypt, West and East Indies and in most tropical countries. The seeds are aromatic, with a musk-like odour, used by perfumers to give a musky odour to sachets and hair-powder. They yield 0·1 to 0·3 per cent. of oil, known as "oil of ambrette" or "musk seed" oil, and the seeds are occasionally imported from the West Indies to London, from Java to Holland, and from Martinique to France, at prices varying from about 1*s.* to 2*s.* per lb. The cultivation would be much the same as for *Hibiscus cannabinus*, *q.v.* p. 531, under Fibres. The oil is usually expensive and does not appear to be largely used.

"Oil of ambrette."

Ajowan. *Carum Copticum.*

An annual plant growing to a height of about 2 feet; flowers and fruits freely and is in general not difficult to cultivate. The oil is an important source of thymol, a valuable antiseptic, of which it contains from 40 to 50 per cent. India is perhaps the chief source of supply of the raw

"Ajowan" oil.

[1] Perfumery and Essential Oil Record, April 1924, "A Revival of Patchouli Cultivation in Johore," pp. 116–117.

[2] Parry, "Chemistry of Essential Oils" (2nd Ed.), p. 302.

material, but the cultivation has been recommended in the West Indies and other hot countries.

American Wormseed. *Chenopodium ambrosioides.*

American "wormseed" oil.

A sub-erect annual, 2 feet high, sometimes described as a biennial and in general a common weed. Indigenous to tropical Africa, America and widely distributed in many warm countries; naturalised in Florida, California and other parts of the United States, where it is cultivated to a considerable extent in Maryland for medicinal purposes. The plant may be propagated from seed and planted out in the field about 1½ feet apart. The oil is distilled chiefly from the fruit heads; but sometimes from the leafly part of the plant. It has been found to be a good substitute for thymol, recommended for the treatment of ankylostomiasis or hookworm disease of miners and as a vermifuge in general. The oil of American wormseed in December 1926 was quoted at 15*s.* 3*d.* to 15*s.* 6*d.* per lb. spot prices, or 14*s.* 3*d.* to 14*s.* 6*d.* c.i.f. for shipment. It was valued at 13*s.* to arrive, or 12*s.* 6*d.* c.i.f. (June 1927).[1] The value is usually based on the percentage of "ascaridole" in the oil.

Cananga or Ylang Ylang. *Cananga odorata.*

"Cananga" or "ylang ylang" oil.

A tree, cultivated in the Philippines, Java, India, &c. The oil is distilled from the flowers. Propagated by seeds in nursery beds, the young plants are ready for transplanting when about 1 foot high. In the plantation they require a space of from 15 feet (193 trees per acre) to 20 feet (109 per acre) apart. It is advisable to keep the trees topped to a height of from 6 to 10 feet, to encourage branching and so ensure a good supply of flowers. The trees begin to flower when about five years old, two crops a year being obtainable, amounting to about 120 lbs. It takes 350 kilog., or approximately 750 lbs. of flowers, to produce a kilog. of

[1] Chemist and Druggist Trade Reports, December 1926 and June 1927.

oil. The best oil is distilled in Manila.[1] The oil of commerce comes in as "cananga" from Java and neighbouring countries, and as "ylang ylang" from the Philippines; although the botanical source is the same, different values are usually placed upon them, the difference in quality being due, it is believed, to climatic and soil conditions. The yield is 1·5 to 2·0 per cent.[2] Recent quotations for cananga oil from Java have been 15*s.* c.i.f. to 19*s.* per lb. spot.

Yield. Market prices

Cassie. *Acacia Farnesiana.*

A thorny shrub 4 to 5 feet high or a small tree 12 feet and upwards, widely distributed in tropical and subtropical regions of the world, including Philippines, Guam Island ("aromo"), S. United States ("opoponax"), Texas ("haisache"), Nigeria ("bonni"), Gold Coast, Angola, Uganda, Congo, N. Africa, Southern Europe, Syria, &c. The names in brackets are those under which the tree is known in the respective countries. "Cassie" is the name in France, Algeria, &c. Under this name it is largely cultivated on the Riviera for the sake of the choice perfume obtained from the flowers, from which the oil of "Cassie" may be distilled, but for perfumery purposes the flowers are usually treated by the enfleurage process (see p. 589); two kilos of flowers being estimated to perfume 1 kilo of fat.[3] The production of recent years has been extended to Syria.

Oil of "cassie."

Propagation and Cultivation.

The tree may be propagated by seeds, which germinate more readily after soaking, raised in nurseries, and the young plants when strong enough may be put out in permanent places about 12 feet apart. A good soil, which should be well drained and of good depth, a moderate rainfall and exposure to full sunlight are desirable conditions. The trees begin to flower in three years after planting, and

[1] Poucher, "Perfumes and Cosmetics," p. 42.
[2] Bennett, Perfumery and Essential Oil Record, November 1912, p. 30.
[3] Piesse, "Art of Perfumery."

when full grown or about 12 feet high may yield about 2 lbs. of flowers. Cassie is cultivated generally for decorative purposes, and if kept well cut makes a good hedge plant.

Cajaput. *Melaleuca leucadendron* var. *minor*.

"Cajaput" oil.

A small tree, native of Malaya. The oil, which is distilled from the leaves, is imported from Malaya, Singapore, Java, Pacific Islands, Celebes, Amboyna, &c., usually in ordinary wine bottles. A recent quotation on the London market is 2*s.* 5*d.* per lb.

The following important sources of essential oil have already been dealt with in respect of cultivation of the plants :—

Clove. *Eugenia caryophyllata*.

"Clove" oil.

Eugenol and synthetic vanillin.

The oil is distilled chiefly from the unopened flower buds —the spice of commerce ; it contains 85 to 95 per cent. of eugenol, used in the manufacture of synthetic vanillin, also used in perfumery and medicine. Vanillin from cloves was recently quoted at 17*s.* 6*d.* per lb. Large quantities of cloves, as already stated (p. 283), come in from Zanzibar and Pemba, and the oil is largely distilled in the countries of import, English distilled recently being quoted at 6*s.* per lb. Essential oil containing a high percentage of eugenol, may also be obtained from the roots. See p. 279 for cultivation.

Pimento or "Allspice." *Pimenta officinalis*.

Pimento.

The oil is distilled from the berries—Jamaica, the chief source—used in perfumery and for somewhat similar purposes in medicine as oil of cloves. The oil also contains 55 to 75 per cent. of eugenol (see p. 284).

Bay, West Indian Bay, Wild Clove or Cinnamon. *Pimenta acris*.

Oil of bay is distilled from the leaves, of which large quantities after being collected are simply dried and baled,

and imported into America and Europe for distillation. "Bay" oil. The oil is also distilled in the West Indies, recent quotations on the London market being 7*s.* to 8*s.* 6*d.* per lb. Eugenol to the extent of 50 to 75 per cent. is the principal constituent; but perhaps the chief use of bay oil is in the "Bay rum." preparation of "bay rum"—in the proportion of 1½ pints to a puncheon (100 gallons) of white Jamaica rum. The oil is obtained chiefly from wild sources in Montserrat, Dominica and other parts of the West Indies, but where this is failing cultivation is recommended. Both species of *Pimenta* are natives of the West Indies and Central or South America, and the cultivation is approximately the same; the main difference being that *officinalis*—since it is fruits that are required—would be planted out 15 to 20 feet apart for full development, and *P. acris* the leaves being the main product—may be planted out at 5 to 10 feet apart or about half the distance, and kept cut down to form bushy plants of a convenient height. The yield of leaves after about two years would be approximately 3,000 lbs., and after five years 9,000 to 10,000 lbs. (see p. 287).

Oil distilled from leaves of *Pimenta acris.*

CINNAMON. *Cinnamomum zeylanicum.*

Cinnamon oil from leaf and bark.

An oil is distilled from the leaves and from the bark. Both oils may be obtained from the plant grown as for spice under a system of coppicing or from older trees. Cinnamon leaf oil is produced on a large scale in Ceylon and Seychelles, a recent quotation for imports into the London market being 5*s.* 10*d.* per lb. (June 1927). It is the principal oil produced in the Seychelles, and in the Report of the Department of Agriculture for 1926 the exports were given as 50,000 litres per annum. The chief constituent is eugenol (75 to 90 per cent.), which, as already stated, is in demand for preparation of artificial vanillin, whereas the chief constituent in cinnamon bark oil is cinnamic aldehyde (55 to 75 per cent.) (see p. 287).

Chief constituent eugenol in leaf oil, and cinnamic aldehyde in bark oil.

Nutmeg. *Myristica fragrans.*

Nutmeg oil.

The volatile "oil of nutmeg" is distilled from the dried seed from which the testa has been removed. They contain 8 to 15 per cent. The "mace" or the arillus also yields 4 to 15 per cent. of oil possessing similar characters and properties. The oil is used in perfumery, soap-making, and as a flavouring in cooking and in dental preparations (see p. 270).

Camphor. *Cinnamomum Camphora.*

Camphor oil.

Camphor oil is a by-product in the distillation of camphor: two kinds of oil, light and heavy, being obtained in the process: the light containing terpenes chiefly, and heavy consisting of safrol in the greater proportion. As already explained, some trees yield only oil, others certain proportion of oil and solid camphor. The value (July 1927) is 75*s.* per cwt. for Japanese camphor oil (see p. 359).

Ginger. *Zingiber officinale.*

Ginger oil.

The odour and pungency of ginger is due to the volatile oil it contains (about 1·5 per cent.); the Jamaica peeled ginger being generally regarded as the best. It is used medicinally and for flavouring, &c. A recent quotation for oil of ginger on the London market was 23*s.* per lb. (see p. 293).

Cubebs or Java Pepper. *Piper Cubeba.*

Cubeb oil.

A climbing shrub, native of Java and the Moluccas. The cultivation is easy; plants may be conveniently grown at the foot of shade trees in coffee plantations, &c (see under Drugs, p. 360). Both fruits and oil are official in the British Pharmacopœia, and Java probably supplies the demand, which would appear to be more or less limited. The berries are coarsely ground and distilled with steam, the yield of oil being from 10 to 18 per cent.[1]

[1] Parry, *loc. cit.*, p. 202.

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"The Oil Grasses of India and Ceylon (*Cymbopogon, Vetiveria* and *Andropogon* spp.)," by Dr. O. Stapf in Kew Bulletin, No. 8, 1906, pp. 297–363. This Bulletin also includes Notes on "Cultivation of *Citronella* Grass in Java," p. 363, and "Cultivation of Lemon Grass in the Malay Peninsula," p. 364. (H.M. Stationery Office, London.)

APPENDIX

THE following Table, showing the number of plants to the acre at various distances, and the area in square feet available for each plant, will be found useful to the young planter:—

Feet apart.	Square feet to each Plant.	Number of Plants to the acre.	Feet apart.	Square feet to each Plant.	Number of Plants to the acre.
1 × 1	1	43,560	7 × 7	49	889
2 × 1	2	21,780	7 × 8	56	778
2 × 2	4	10,190	8 × 8	64	681
2 × 3	6	7,260	9 × 9	81	538
3 × 3	9	4,840	10 × 10	100	435
3 × 4	12	3,630	12 × 12	144	302
4 × 4	16	2,722	15 × 15	225	193
4 × 5	20	2,178	16 × 16	256	170
5 × 5	25	1,742	17 × 17	289	151
5 × 6	30	1,452	18 × 18	324	134
6 × 6	36	1,210	20 × 20	400	109
6 × 7	42	1,037	25 × 25	625	69

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